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TELEVISION FUNDAMENTALS

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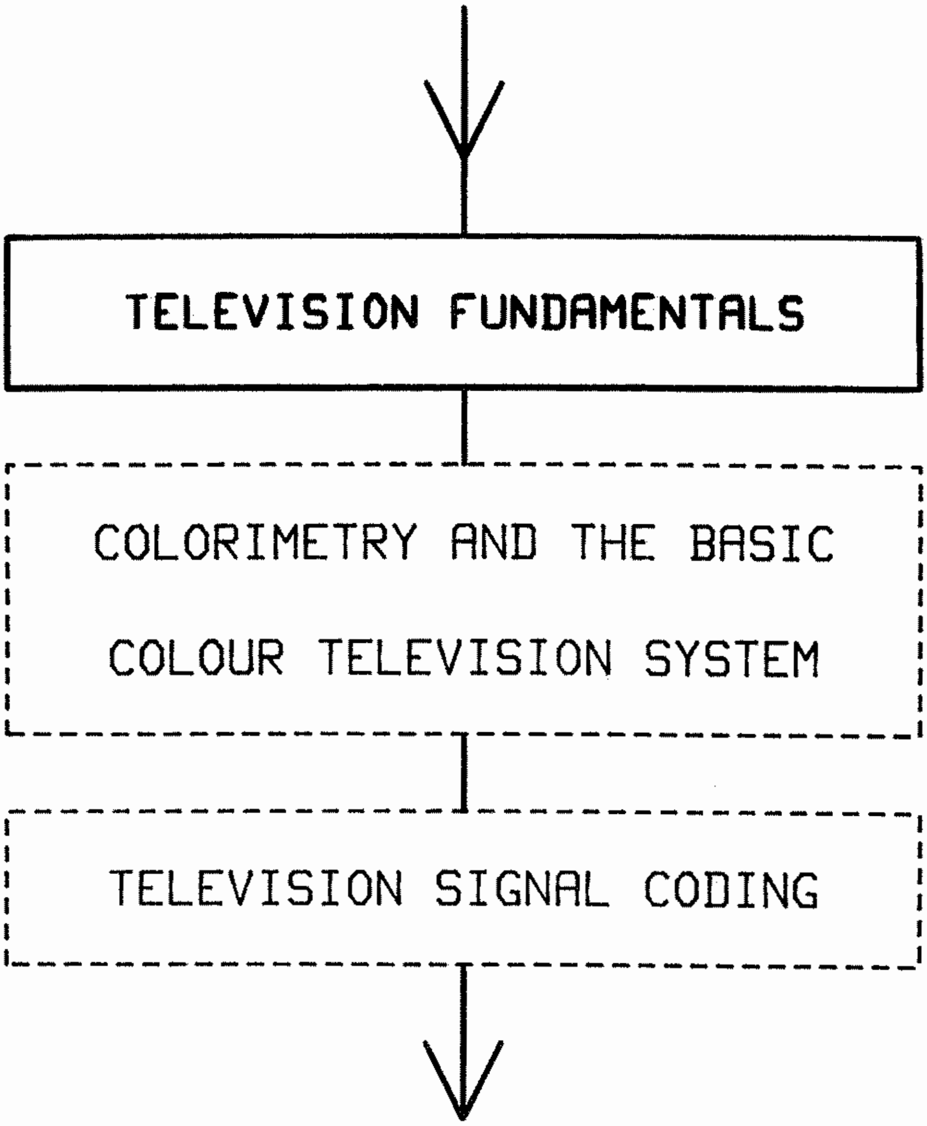
TELEVISION FUNDAMENTALS
COLORIMETRY AND THE BASIC COLOUR TELEVISION SYSTEM
TELEVISION SIGNAL CODING

SUBJECT STRUCTURE

There are three packages in the Television Principles Module.

This first package deals with the basic principles of television and develops the requirements of a basic monochrome (black and white) system. The television signal is constructed step by step and some particular circuit techniques are considered. Emphasis is placed on describing the U.K. 625 line system.

The second package studies Colorimetry and describes how its principles can be used together with the monochrome television system to provide a Basic Colour Television System.

The third package developes further the basic colour television system into the final system. The NTSC system is considered first and then the British PAL system. Reference is also made to the SECAM system.

AIMS OF THE PACKAGE

The broad aims of this package are:-

1. To explain the scanning process used in television systems.
2. To describe the characteristics of the monochrome television signal and explain the uses of its component parts.
3. To describe the problem raised by the non-linearity of the picture tube, Gamma, and its solution.
4. To consider the problem of the d.c. component of a television signal, its removal for signal distribution and how it can be reinserted.
5. To outline the standards of the U.K. 625 line television systems.

PACKAGE STRUCTURE

This package consists of two written units and some demonstration equipment. This unit deals with the theory of monochrome television and the other contains details of the practical work to be carried out on the demonstration equipment.

STUDY GUIDE

When a practical demonstration or investigation is necessary, the theory unit will direct you to the appropriate activity in the practical unit. You should then leave the theory unit and undertake the practical activity as instructed. If however, the practical equipment is not available at this time, you may continue with the theory unit, but the practical should be undertaken as soon as possible.

Throughout the package you will find a number of questions to answer or waveforms to draw. Spaces are provided within for you to answer the questions or draw the waveforms as required.

Please make genuine attempts to solve these before continuing. If you experience any difficulty in providing the answers then consult your tutor.

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SECTION 1

SCANNING

TELEVISION FUNDAMENTALS

INTRODUCTION

This package is concerned with the study of MONOCHROME television fundamentals, that is black and white television.

What is television?

The British Standards Institution has defined it as 'the art of instantaneously producing at a distance a transient visible image of an actual or recorded scene by means of an electrical system of communication, with or without its accompanying sound'.

A simplified view is that continuous variations in the quantity of light in a scene (shades from black through the greys to white) are reproduced at a distant point. Light is converted to electricity which in turn is converted back to light.

The diagram below represents a simple television system.

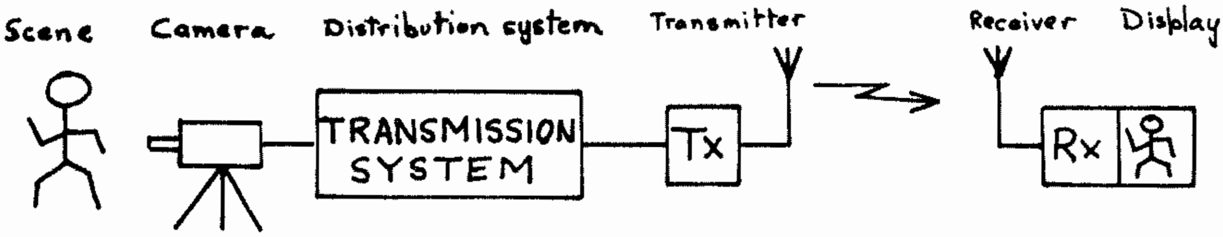


Figure 0.1 Simple Television System

The sound signal is not considered here. The drawing is a simplified example. More than one camera would normally be used in a programme or the source could be a video tape, film or an electronic signal generator or any combination.

SECTION 1: SCANNING

1.1 Sampling

The problem is to convey the different levels of brightness (or LUMINANCE) of the scene to the distant image forming device. The picture seen by a viewer is a two-dimensional display consisting of areas of different brightness. A single signal cannot give the instantaneous levels of brightness in all of the different parts of the scene at the same time.

How can it be done?

Well, if the whole scene cannot be covered instantaneously, then small parts (called ELEMENTS) must be considered individually. If the scene to be viewed is divided up into square elements a mosaic-like effect is produced. A 48 element mosaic is shown in Figure 1.1. To resolve fine detail of a general scene, a minimum of about 200,000 elements are needed. Ideally corresponding elements at the scene and the image will have the same brightness.

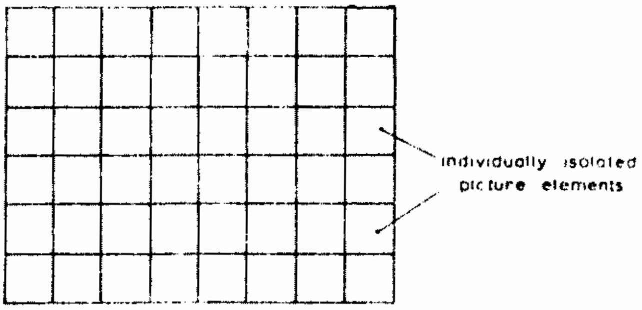


Figure 1.1. Mosaic like construction of photo sensitive layer.

Theoretically, a separate channel to convey brightness information for each element could be used. This is not practical and another approach must be made.

The answer is to consider each element in turn, a form of Time Division Multiplex. Each element is sampled in turn and the equivalent electrical signal sent to the distant display system.

The sampling process is called SCANNING. A single electrical signal is produced the level of which, at any instant, represents the brightness level of the element being sampled at that time.

1.2 CHARGE STORAGE MOSAIC

This section gives a very much simplified explanation of the basic operation of a television camera pick-up tube. The object is to give an extremely simple idea of how the electrical signal is derived.

The tube is the heart of a television camera and produces the electrical signal equivalent to the light from the scene viewed by the camera. Light from the scene is focussed through a transparent conducting surface onto a target made of photo-conductive material. The target can be considered as consisting of many separate elements. The light falling on these elements causes a charge to be formed that is proportional to the light falling on the element. Effectively the elements are capacitors that are discharged proportionally to the light present. One side of each of the capacitors is joined to the conducting surface, called the 'signal plate'. When an electron beam is focussed onto an element, then electrons from the beam recharge the capacitor and current flows from the signal plate through a resistor. The voltage across the resistor is thus proportional to the recharge current for the element being sampled.

The beam then samples the next element, then another and so on. The resultant electrical signal is proportional to the charge supplied to the element being sampled, and hence its brightness - it is called the PICTURE SIGNAL.

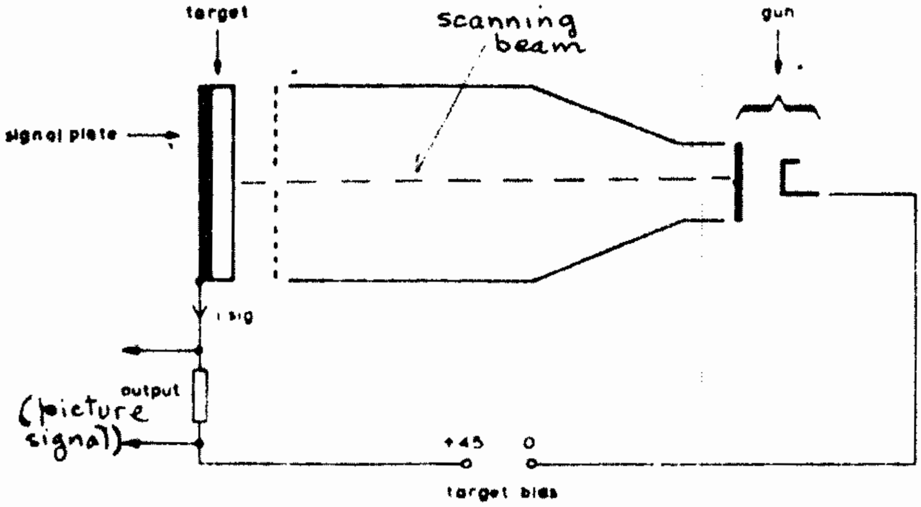


Figure 1.2 Basic Camera Pick-up Tube Circuit

1.3 SEQUENTIAL SCANNING

Electron beam scanning is achieved by simultaneous horizontal and vertical deflection of the beam.

A simple form of scanning is where the beam starts at the top left hand side of the mosaic and travels across to the right, sampling each element in the top row. The beam then returns to the left hand side but has been deflected down to the second top row, which it then samples. This continues until every element in every row has been sampled. When the beam reaches the right hand side of the bottom row it returns to the left hand side at the top and starts again. This is known as SEQUENTIAL SCANNING.

The beam deflection system has two components, a slow vertical one and a fast horizontal one. The horizontal and vertical deflections are doing the same job but at a different frequency.

The deflection system can be either electrostatic or electromagnetic, that is, dependant on voltage or current. Electromagnetic deflection is used in camera tubes and picture tubes. The deflection waveforms are not transmitted, they are regenerated in the receiver. Synchronisation information must therefore be sent to maintain the essential relationships between the camera and receiver scans.

Figure 1.3 shows the scanning waveform. Remember that the amplitude and duration of horizontal and vertical waveforms are different.

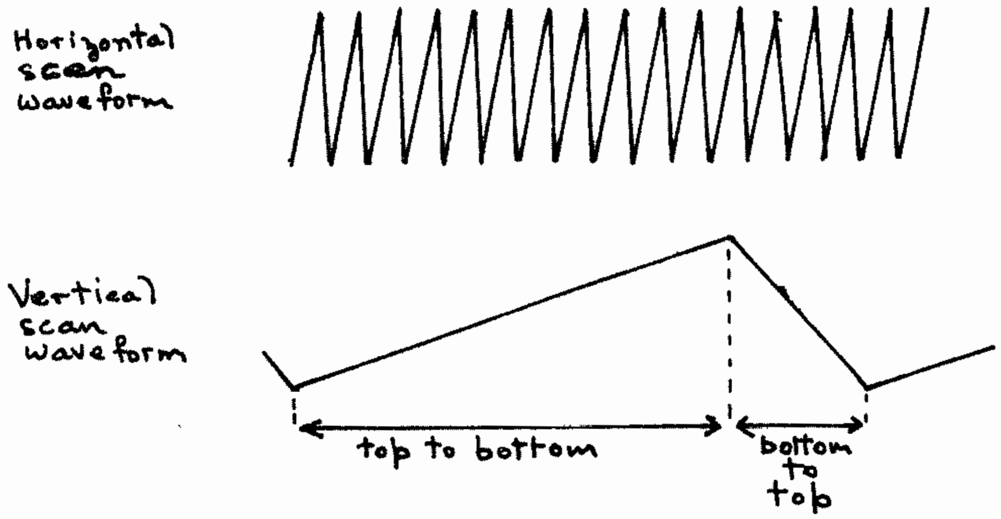


Figure 1.3 Waveform required in deflection circuits of scanning systems

The pattern traced out by the beam is called a RASTER. Figure 1.4 shows a 9 line sequential raster. This method of scanning uses a horizontal, left-to-right, constant velocity scanning technique with a rapid return (called LINE FLYBACK) to scan the next line below in the same way. The beam is also subject to a much slower top-to-bottom constant velocity deflection component. This means that the lines are not absolutely horizontal but slope slightly downwards from left to right. When the beam reaches the bottom of the scene there is a rapid return to the top of the raster to start another scan, this is called VERTICAL FLYBACK.

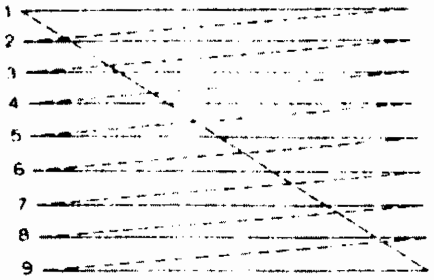


Figure 1.4 9 line Sequential Raster [Flyback path shown dotted]

The vertical flyback is much faster than the top-to-bottom deflection but is slower than the time to scan several lines. If the horizontal deflection system runs continuously (as it does in practice) then the beam will zig-zag back to the top.

1.4 SCANNING SPEED

The time taken to sample all the elements in a scene once is called the PICTURE PERIOD. The number of complete pictures scanned in one second is called the PICTURE FREQUENCY. The LINE FREQUENCY is the product of the number of lines in a system multiplied by the Picture Frequency.

The scanning speed is a function of Picture Frequency, that is, the more prictures that are scanned in one second then the higher is the scanning speed. As the scanning speed increases so does the rate ar which the elements are sampled, consequently the maximum frequency generated is increased. In the interest of bandwidth economy it is therefore desirable to keep the Picture Frequency as low as possible.

Question

What factors determine the Picture Frequency? Think in terms of the motion picture industry and how it portrays movement. Make brief notes of your answer.

The value of Picture Frequency is controlled by the need to protray movement without jerkiness. The film industry was the pioneer in this study.

A series of still pictures are shown quickly, one after the other, and the eye sees tham as a moving scene. Each still picture is called a frame. It was found that movement was portrayed by 20 to 25 pictures per second, but, the avoid a flicker effect, about 50 pictures per second were needed. The higher rate would use twice as much film as the lower one, but it was found that by switching off the projector light whilst a frame was stationary in the gate, as well as when a new frame was being pulled into it the apparent flicker rate was doubled. They settled on a Picture Frequency of 24 per second, thus the flicker rate was 48 per second. This meant that acceptable flicker performance was achieved without doubling the quantity of film used.

1.5 INTERLACE SCANNING

INTERLACE SCANNING is used in television to keep down the required bandwidth in a similar way to that in which the film industry reduced the amount of film needed.

In INTERLACE SCANNING alternate lines are scanned in time sequence. When the trace reaches the right hand side of the first line it flies back to the left hand side, but, instead of next scanning the line below the one just scanned, it scans the next but one. This continues until the beam reaches the bottom when it flies back to the top and starts another vertical scan. This time it scans the intermediate lines that were not sampled in the previous scan. This means that two vertical sweeps of the screen must be made to sample all the elements in a scene and thus get a complete picture.

Each sweep is called a FIELD.

FIELD FREQUENCY is twice Picture Frequency for simple Interlace Scanning. In the U.K. 625-line system Field Frequency is 50 Hz and Picture Frequency is 25 Hz. In the terms used in the film industry example the Picture Frequency is 25 Hz and the Flicker Rate is 50 Hz. If Sequential scanning was used the Picture Frequency would have to be 50 Hz to avoid flicker, and consequently the maximum frequency generated would be doubled.

Interlace Scanning does not increase the scanning speed and thus does not increase the required bandwidth. (Scanning speed is proportional to Picture rate).

To keep the vertical deflection system simple the vertical flyback is arranged to start halfway along the last line of the first, and alternate, fields. This means that an odd number if scanning lines must be used in each complete scan of the mosaic.

Figure 1.5 shows a 9-line Interlaced Scan raster.

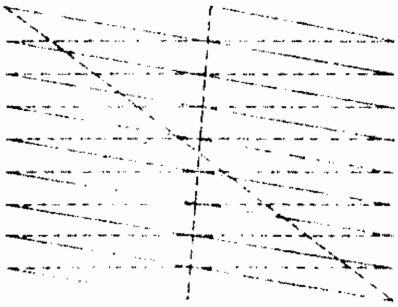


Figure 1.5 9-line Interlaced Raster (Flyback paths shown dotted)

Bandwidth requirements are discussed in detail later.

The use of 625 lines with a Picture Frequency of 25 Hz gives a line frequency value of 15.~~526~~ 15.625KHz kHz, however amuch more useful figure is the duration of one line, which is 64 µs.

Go to the demonstration equipment and display the 13-line raster for both sequential and interlaced scanning.

1.6 ASPECT RATIO

The ratio of width to height of the viewed rectangle is called the ASPECT RATIO. The choice of Aspect Ratio is one of aesthetic appeal, the British Systems now use 4:3 which at the time conformed to that most commonly used by the motion picture industry.

SECTION 2

THE TELEVISION WAVEFORM

SECTION 2 THE TELEVISION WAVEFORM

2.1 PICTURE SIGNAL

The Picture Signal has already been mentioned and is a current or voltage that varies according to the brightness level of the scene element being sampled at that time. It varies between two defined limits, one limit represents zero brightness, called BLACK LEVEL, the other limit represents maximum brightness and is called WHITE LEVEL.

Figure 2.1 depicts a scene consisting of four vertical band of different brightness levels, dark grey, mid-grey, light grey and white.

The picture signal obtained by scanning the scene is also shown in figure 2.1.

Whilst the beam is flying back to scan a new line, the picture signal must not contain information. It must be BLANKED. BLANKING means holding the signal down at black level to ensure that no picture information is present during flyback.

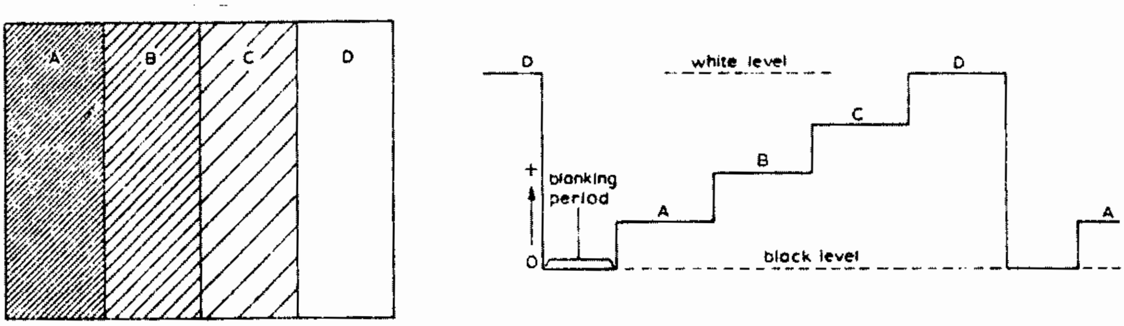
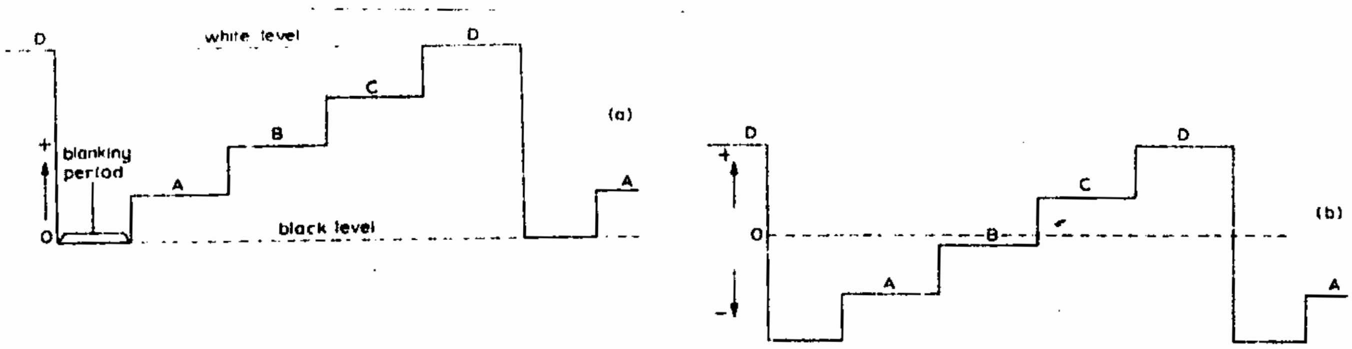


Figure 2.1 Simple test pattern and associated waveform

Black level is the minimum brightness, any other possible brightness level causes a signal level change in one direction only, increasing from black towards white. The picture signal is undirectional and has a d.c. component corresponding to the mean brightness of the scene.

The d.c. component creates a problem. If the d.c. component is maintained at all points in the distribution chain it means that d.c. coupling must always be employed. This is technically difficult and expensive. It is easier to use a.c. coupling and employ special techniques to reinsert the d.c. component when required.

This is discussed later in greater detail.



(a) with the d.c. component (b) without the d.c. component

Figure 2.2 Picture signals obtained by scanning one line of the simple test pattern.

2.2 BLANKING

During the flyback periods the sampling process is suppressed and the picture signal falls to zero, that is black level. These gaps are called blanking periods and allow time for the camera and the receiver line and field flybacks to take place. The line blanking is a proportion of line time, the field blanking covers several lines. The blanking signals are not part of the video waveform, they are only used in cameras and other signal generation equipment and are called LINE BLANKING and FIELD BLANKING.

What form do they take? Give shape and approximate timing and duration.

Question What do you think is the shape and approximate timing and duration of the Line Blanking and Frame Blanking waveforms?

They are rectangular pulses which occur at appropriate times and are of the required duration. In practice, line blanking and field blanking signals are combined to form a single signal called MIXED BLANKING.
Line blanking occurs at the end of a line and is about one fifth of a line duration. Field blanking occurs at the end of a field and has the duration of several lines.

Go to the demonstration equipment and display a 625-line TV waveform, say Test Card, on the oscilloscope and measure the duration of:-

a) The Line Blanking period.
b) The Field Blanking period.

Line blanking is 12 us.

Field blanking is 25 lines + 1 line blanking period, about 1.6 ms.

Q. What effect would be seen on a screen if the signal was not blanked during flyback?

A. The flyback traces would be visible. (What would be the effect on the picture signal out of the camera if the scanning beam is not suppressed?)

Field blanking starts about 2.5 lines before field flyback occurs.

The scanning beam is suppressed in receivers during the flyback periods.

2.3 SYNCHRONISATION

2.3.1 General

It is economically desirable to use one channel only to convey all the information required to enable the viewed scene to be accurately reproduced. It is not necessary to send the scanning waveforms. It is necessary to send information to synchronise scanning, and thus obtain positional information about the elements, along with their brightness.

2.3.2 Line synchronisation

The required information has to indicate when a line ends (or starts) and also when a field ends (or starts). In broadcasting, the synchronising information tells the receiver when to start the line and field flyback.

This information is put into the blanking periods. The picture signal is unidirectional w.r.t. black level (it could be negative or positive w.r.t. black, depending on whether or not it has been inverted by an amplifier, but never negative AND positive w.r.t. black level). The synchronising information is arranged to be of opposite electrical polarity to that of the picture signal and is thus easily distinguished from it. The synchronising signals are in the form of rectangular pulses. These synchronising pulses are called line synchronising pulses and field synchronising pulses, often abbreviated to 'line syncs' and 'field syncs'.

The line sync pulse is carefully positioned inside the blanking period to give a period of blanking level before and after the sync pulse. These periods of blanking level are called the FRONT PORCH and the BACK PORCH.

Synchronisation problems could occur if there was not a front porch and thus the picture signal period continued right up to the start of the sync pulse. The edges of syncs are not vertical but have specific rise and fall times. A timebase triggers at a fixed voltage level. For a black scene triggering will occur at a specific time after the start of line syncs.

If the picture signal was at white level at the end of a line, without a front porch, then it would take longer for the signal to fall to the trigger level than for a black scene. Thus the flyback initiating time would vary with picture level.

The front porch gives the sync pulse a constant height at its leading edge regardless of picture content and thus a constant trigger point.

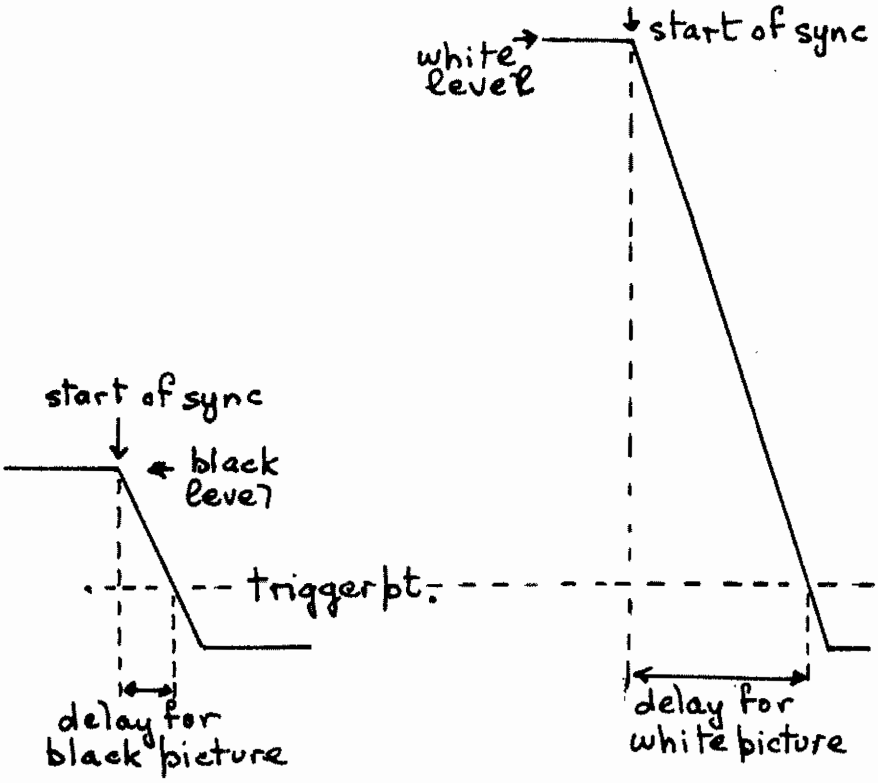


Figure 2.3 Mistriggering with no front porch.
[Horizontal axis expanded: not to scale]

The back porch was instituted to allow the line scanning circuits to complete flyback and provides a convenient black level reference.

The leading edge of the sync pulse is the timing reference for all line frequency components of a television waveform.
Figure 2.4 shows several lines of picture signal with the appropriate line synchronising (line sync) pulses.

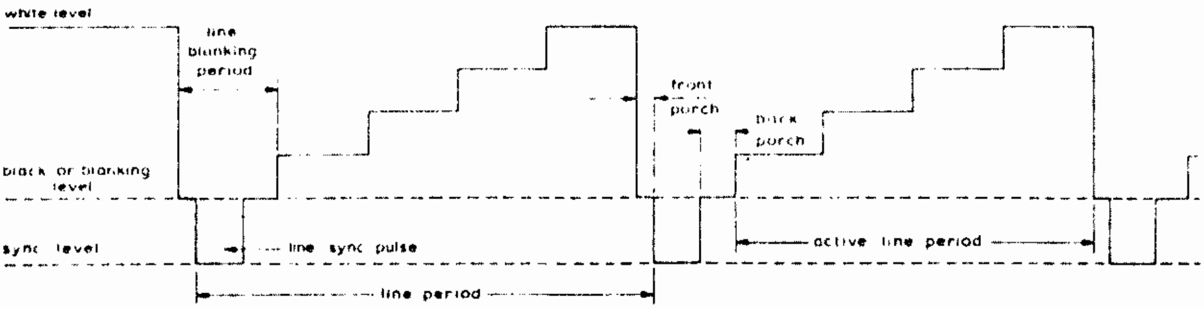


Figure 2.4

The normal method of detecting line syncs in a receiver is by the use of a short time constant differentiating circuit. Circuits called sync separators are used to obtain from the video signal a waveform that consists of sync pulses only and this waveform is applied to the differentiating network. If the waveform of Figure 2.5 is applied to a differentiating circuit with a short time constant (w.r.t. sync pulse period) draw the output waveform.

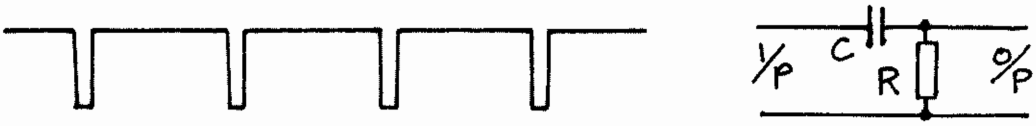


Figure 2.5

Figure 2.6 shows the output from the differentiating circuit. The positive going spikes are ignored leaving a series of spikes coincident with the leading edge of line syncs.

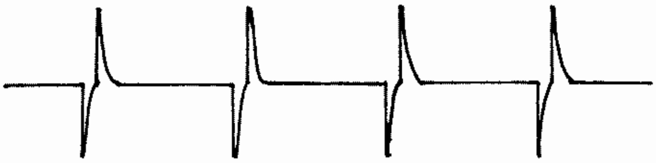


Figure 2.6

2.3.3 Field Synchronisation

The field sync and the line sync pulses must be different. The polarity is fixed so their duration must differ, the field sync signal used is much longer than the line sync.

Most television systems use a field synchronising pulse which lies between 2.5 and 4 times that of a single line period. For example, the UK 405-line system has a field sync period of 3 times the line period, whilst the UK 625 line system uses 2.5 times the line period.

Electronically it is easy to distinguish between line and field pulses by means of an integrating circuit which has a suitable time constant.

In the UK 625-line system line syncs are 4.7µs duration and the postulated simple field pulse is 2.5 times line duration (64µs), that is about 160µs. About what value of time constant is needed for the integrating circuit to detect the field pulse but ignore the line sync pulses?

A value of at least four to five times the duration of a line sync is needed.

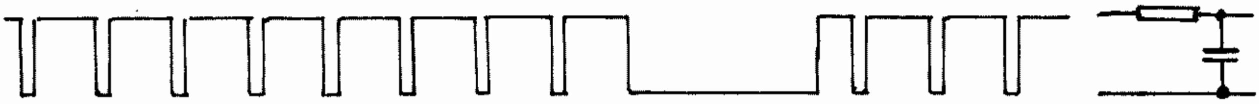


Figure 2.7

The waveform in figure 2.7 represents a train of line sync pulses with a 2.5 line duration pulse representing a simple field sync pulse. This waveform is applied to the circuit shown in figure 2.7, sketch the output waveform. Assume a time constant of about 50µs.

Figure 2.8 shows the output waveform.

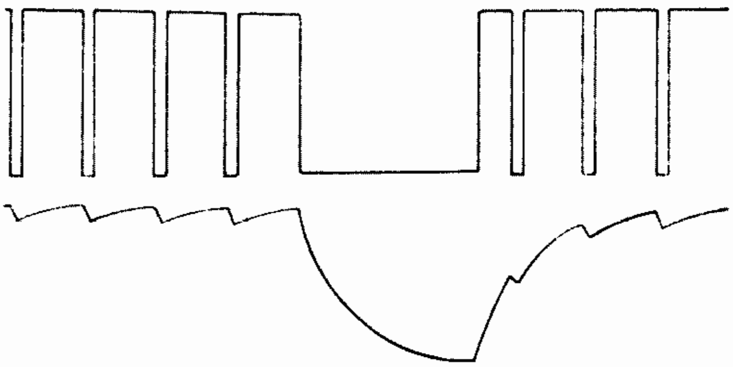


Figure 2.8

Go to the demonstration equipment and demonstrate the effect of a short time constant for detecting line syncs using differentiation and a long one for detecting field syncs using integration.

2.3.4 Field Sync Pulse Construction

It has already been stated that the use of interlaced scanning requires that the field pulse at the end of Field 1 (the start of Field 2), starts half way along a line and that the field pulse at the end of Field 2 (the start of Field 1) starts at the end of a line. The simple long-duration field sync waveform for a 625-line interlaced scanning system is shown in figure 2.9.

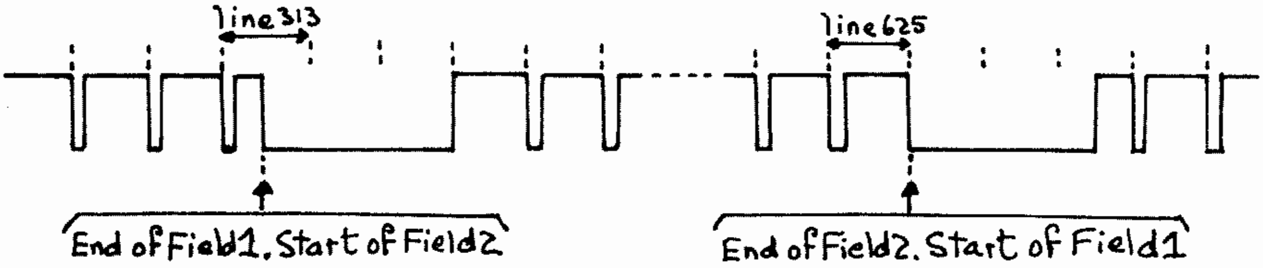

line313
line625
End of Field1. Start of Field2
End of Field2. Start of Field1

Figure 2.9 Simple Long-duration Field Pulses

For several reasons a simple, single, long-duration pulse was not practicable for broadcasting systems and the simple waveform during field blanking was modified in several ways.

Line oscillators, particularly in sets made in the early days of television, needed synchronisation to continue during the field synchronising pulse. This required negative going transitions during the field sync pulse coincident with line sync pulse timings. This meant that additional narrow pulses had to be inserted into each field sync pulse.

The modified waveform to satisfy this requirement is shown below. The waveform at the end of field 2 is shown below as well as alongside that at the end of field 1 to emphasise the difference between them.

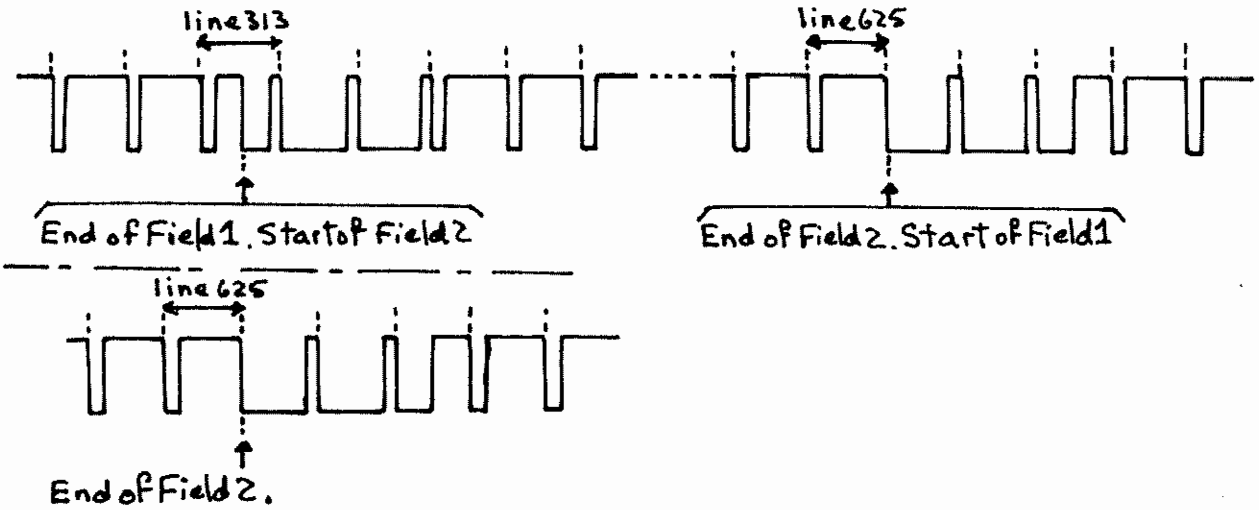

line313
line625
End of Field1. Start of Field2
End of Field2. Start of Field1
line 625
End of Field2.

Figure 2.10

The duration of the positive going pulses that occur during the field sync pulse is the same as that of a line sync pulse, that is, 4.7μs.

The waveforms are now not identical during the field sync periods. If they were applied to an integrating circuit the voltage across the capacitor would not change smoothly, but be briefly interrupted by the narrow pulses. This is shown in the figure below.

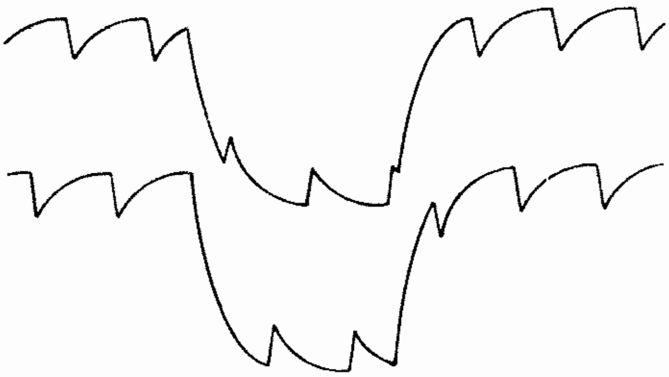


Figure 2.11.

The important point is that the interruptions do not occur at the same time after the start of the field pulse for each field. The first interruption occurs a half-line time after the start of one field and whole-line time after the start of the other. The result is that triggering could occur at different times after the start of the field pulse on the two fields.

This would prevent good interlace. To overcome this, extra pulses were added at half-line periods to each field pulse. The final effect is that there are 5 BROAD PULSES of about half-line duration instead of one pulse of 2.5 line period.

The waveform is shown below.

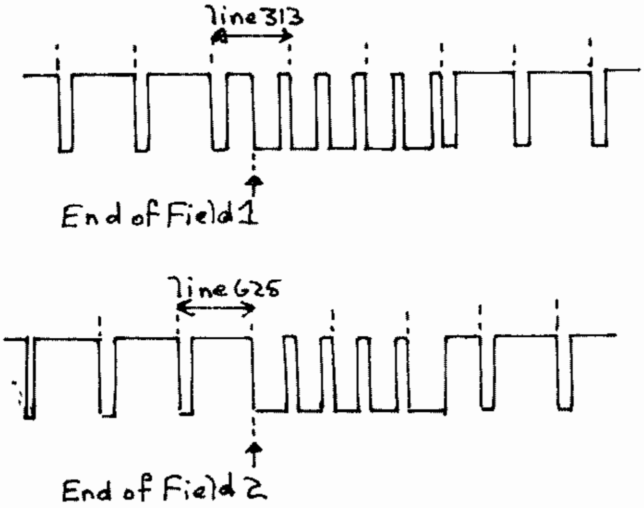


Figure 2.12

The field sync pulses of the two fields are now similar but the pre and post field-pulse periods of the two fields are not similar, again due to the half-line stagger for interlaced scanning.

Although the line sync pulses are not detected by the integrator they do impart a small charge each line to the capacitor. At the end of field 1 there is only a half-line period for the capacitor to discharge before the field sync pulse starts building up charge again. At the end of field 2, however, the capacitor is able to discharge for a whole line period.

In consequence the capacitor starts off with different residual charges on the two fields and thus the charging curves will be different, particularly for the early stages.

Again, poor interlace could result.

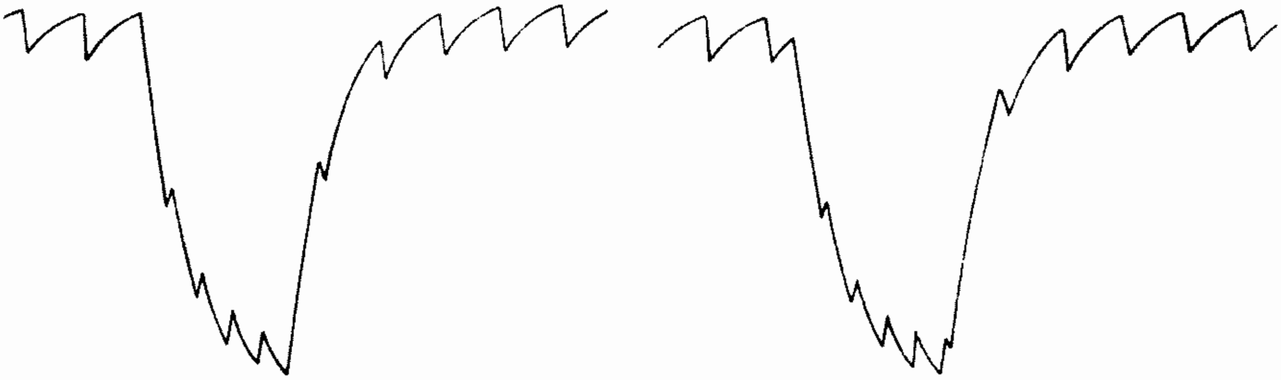


Figure 2.13

The actual voltage trigger level in a receiver is not as important as the fact that triggering should occur at exactly the same time delay from the start of the field pulse on BOTH FIELD 1 AND FIELD 2.

The actual time delay need not be the same in all receivers but the delay MUST be the same in both field 1 and field 2.

To overcome this problem additional pulses called EQUALISING PULSES, are added before and after the field pulse and are at twice-line frequency. The pulses effectively move the half-line offset away from the field pulse so that by the time the field pulse starts the charge on the capacitor is the same on both fields.

There are five equalising pulses before and five after the field pulse. The duration of the Equalising pulses is half that of a line sync, that is 2.35μs.

The final waveform is shown in Figure 2.14.

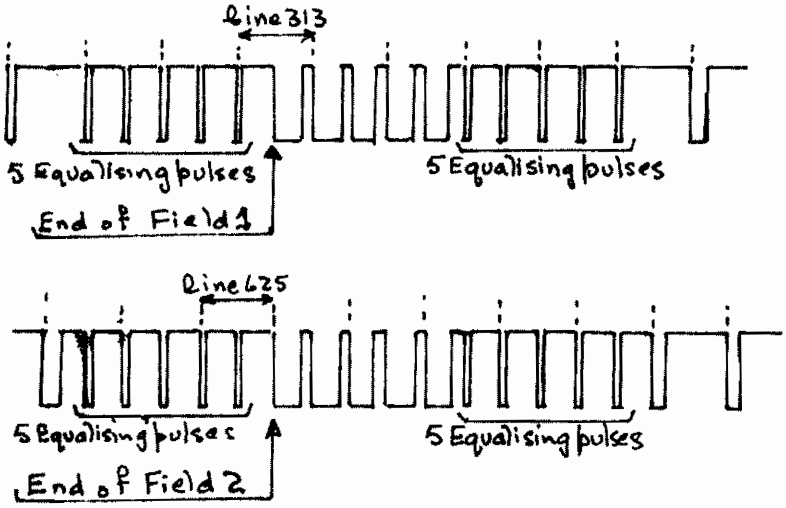


Figure 2.14. Final Field Pulse Waveforms

The output of the integrator is shown in figure 2.15.

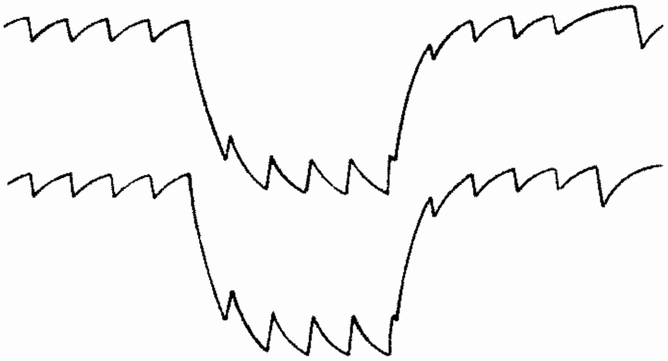


Figure 2.15. Integrator Output using Final Field Sync Pulse Waveforms

Questions

a) Why are the equalising pulses only half the width of line syncs?

b) Why are equalising pulses added after the field pulse?

Answers

a) To maintain the same average value of the signal.

b) To make the trailing edge of the integrated field pulse the same on both fields. In some receivers the integrated field pulse acts as an inhibit on the field scan oscillator. When the trailing edge rises the oscillator restarts at a particular level. If the shape of the trailing edges on both fields is not the same then the oscillator will restart at different relative times on the two fields and the result will be poor interlace.

The prime requirement is that the integrator output waveform should be identical for both fields. The actual level of the trigger point in a receiver is not as important as the fact that it should be achieved at exactly the same time delay from the start of the field synchronisation period on BOTH FIELD 1 AND FIELD 2.

The duration of the five equalising pulses in the two and a half lines before the field pulse and the five in the two and a half lines after the field pulses is 2.35 µs.

Go to the demonstration equipment, build up the waveform in stages. Ensure that the displays of the two field intervals are of identical amplitude, apply integration and observe the effect. Use the vertical shift to overlay the two displays. In the final state jitter will be observed at two and a half lines before and two and a half lines after the field pulse reducing to zero at the field pulse.

Without reference to your notes and starting with the waveform given below develop, step by step, the complete field sync period waveform showing the components added to give:-

a) continuous line triggering

b) field pulse equality on Field 1 and Field 2

c) pre and post field pulse equality on Field 1 and Field 2

Identify Field 1 and Field 2 and number the last line of each of the two fields.

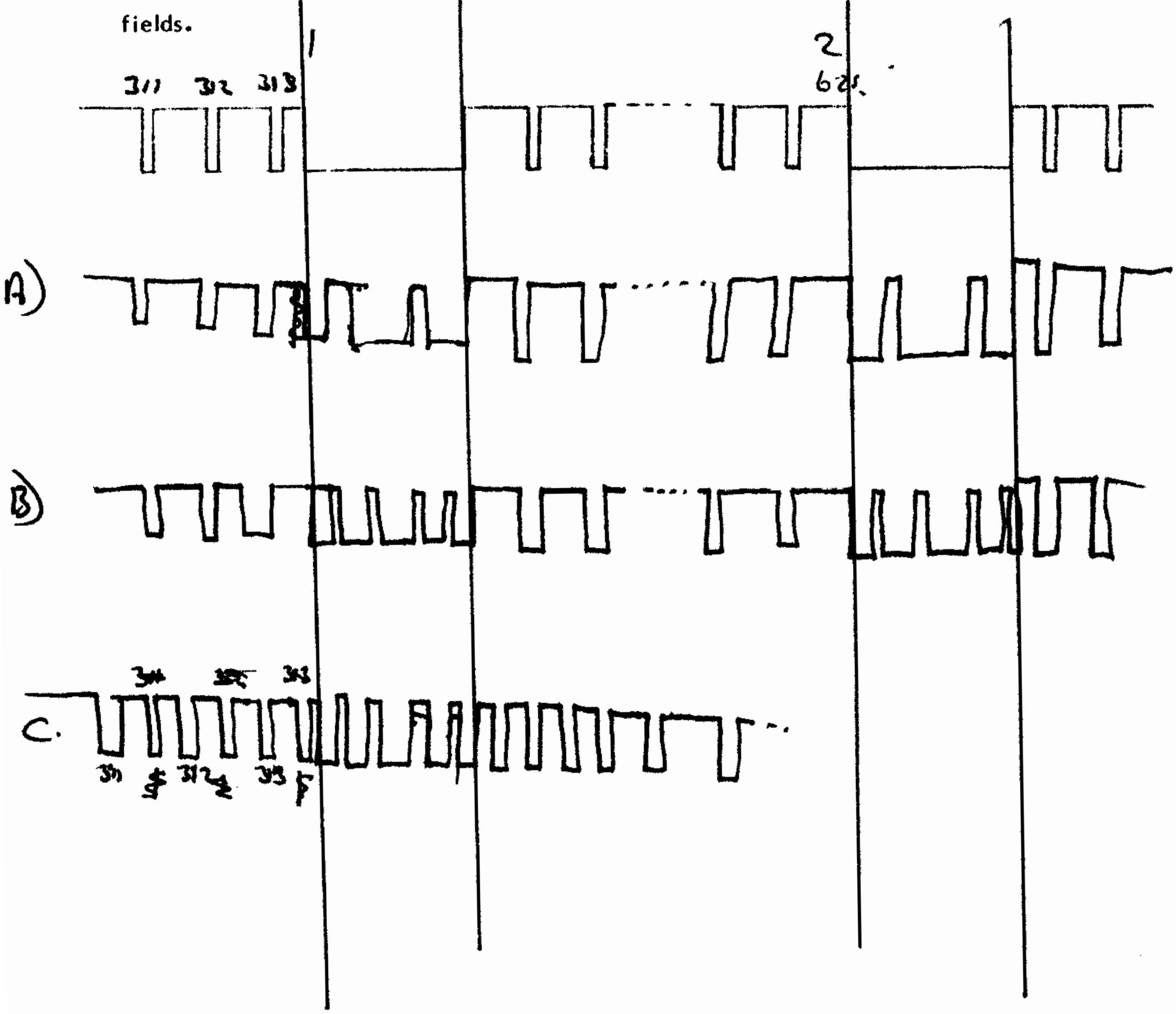


Figure 2.16

2.3.5 Field Sync Derivation Summary

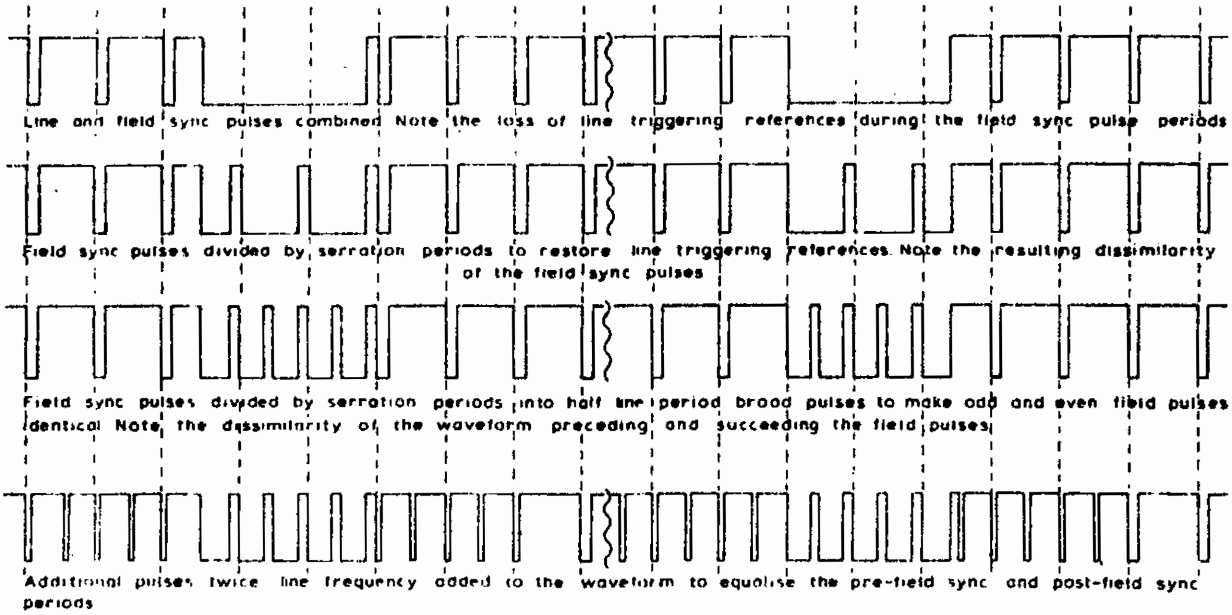
Figure 2.17 shows line and field sync pulses and the derivation of the final field sync period waveshape to

a) preserve line synchronising

b) provide identical field pulses in an interlaced system

c) provide identical pre-field sync and post-field sync periods.

This latter condition makes it easier to obtain correct receiver interlace without using complicated field sync detector circuits and is not included in all standards.



Line and field sync pulses combined Note the loss of line triggering references during the field sync pulse periods

Field sync pulses divided by serration periods to restore line triggering references. Note the resulting dissimilarity of the field sync pulses

Field sync pulses divided by serration periods into half line period broad pulses to make odd and even field pulses identical Note the dissimilarity of the waveform preceding and succeeding the field pulses

Additional pulses twice line frequency added to the waveform to equalise the pre-field sync and post-field sync periods

Figure 2.17 Derivation of final mixed sync waveform to ensure continuous line triggering references and identical Field 1 and Field 2 sync pulse periods

From this diagram, it can be seen that the field sync period is divided into broad pulses that occur at twice line frequency, and condition (c) requires equalising pulses at twice line frequency both before and after the broad pulses. The number of broad and equalising pulses required is not critical and in practice any number of 1 to 8 are used in various world television standards.

A general approach has been used to describe the various parts of the frame synchronising system. Specific names have, of course, been given to these parts as well as duration and timing, these are now defined.

BROAD PULSES

The period is about half-line time duration. There are five in each field synchronising period.

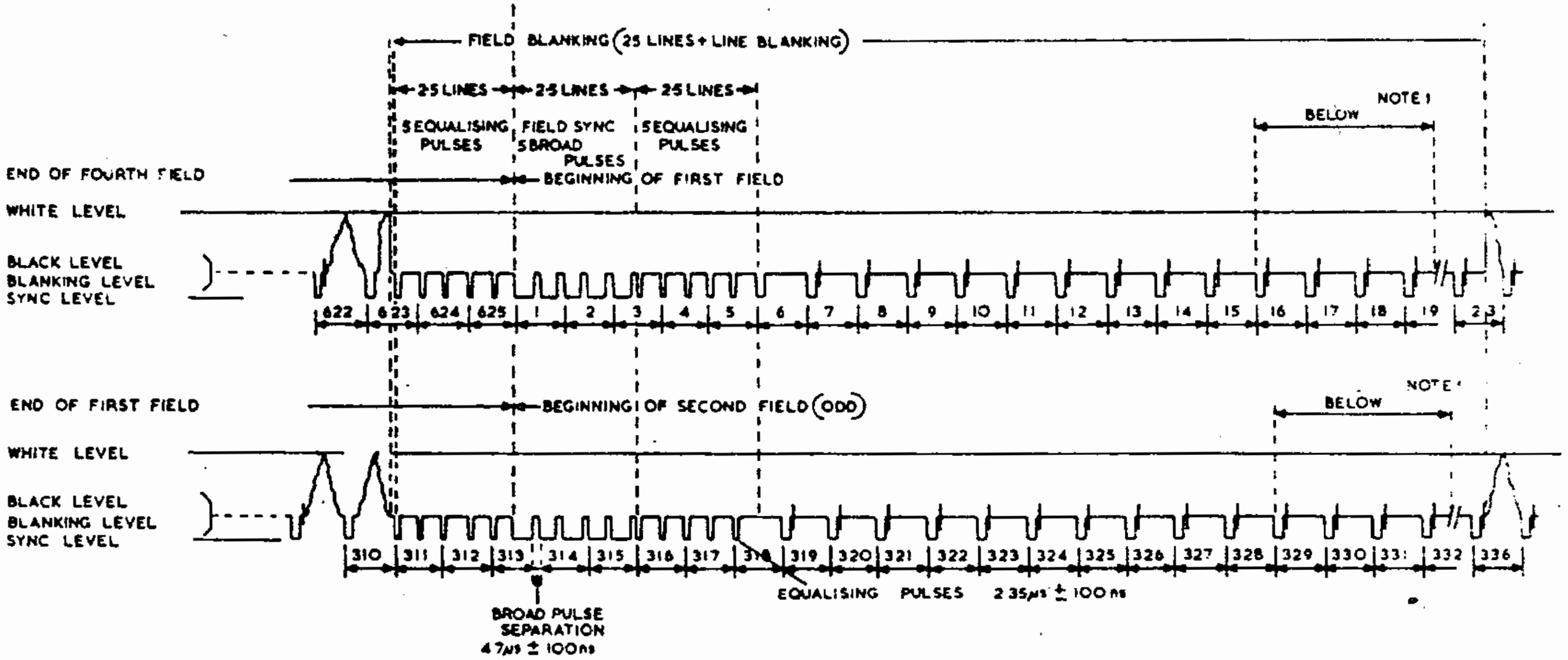
EQUALISING PULSES.

These are the 10 pulses inserted, 5 before and 5 after the broad pulses, to ensure similar pre and post broad pulse waveforms for both odd and even fields. They are of half-line sync pulse duration, that is about 2.3µs.

BROAD PULSE SEPARATION PULSES (SERRATIONS)

These are the intervals between the broad pulses, at black level, and are of the same duration as line syncs, that is about 4.7µs. The trailing edges (negative-going) of alternate pulses are co-incident with what would be the leading edge of syncs in a continuous line sync waveform.

Figure 2.18



NOTE 1

LINES 15 TO 22 INCLUSIVE AND 328 TO 335 INCLUSIVE MAY CONTAIN IDENTIFICATION CONTROL OR TEST SIGNALS (SEE APPENDIX III)

NOTE 2

THE FIRST & SECOND FIELDS ARE IDENTICAL WITH THE THIRD AND FOURTH IN ALL RESPECTS EXCEPT BURST BLANKING (SEE SECTION 4.4.4)

RISE & FALL TIMES 10% 90% PULSE AMPLITUDE

FIELD BLANKING 300 ± 100ns
FIELD SYNC PULSES 250 ± 50ns
EQUALISING PULSES 250 ± 50ns

Eq. Pulse width 2.35μs.
Field Sync. 160 μs
Broad pulse width 27.3 μs.
Line Sync 4.7μs.

Vertical synchronising and blanking waveforms for a typical signal

2.4 THE VIDEO SIGNAL

2.4.1 General

The television signal developed now has brightness information (picture signal) and synchronisation information. The combination of picture signal and synchronising pulses is called the COMPOSITE VIDEO SIGNAL often referred to simply as the VIDEO SIGNAL.

Some other terms defining certain parameters are used. Two of these are ACTIVE LINE PERIOD and ACTIVE FIELD PERIOD.

Q. What do you think these terms mean?

A. Active Line Period - This is the difference between the full line time and the line blanking period.

Active Field Period - This is the difference between the full field time and the field blanking period.

The figure below shows the video signal, two horizontal time scales are used, one showing several lines and one showing two fields.

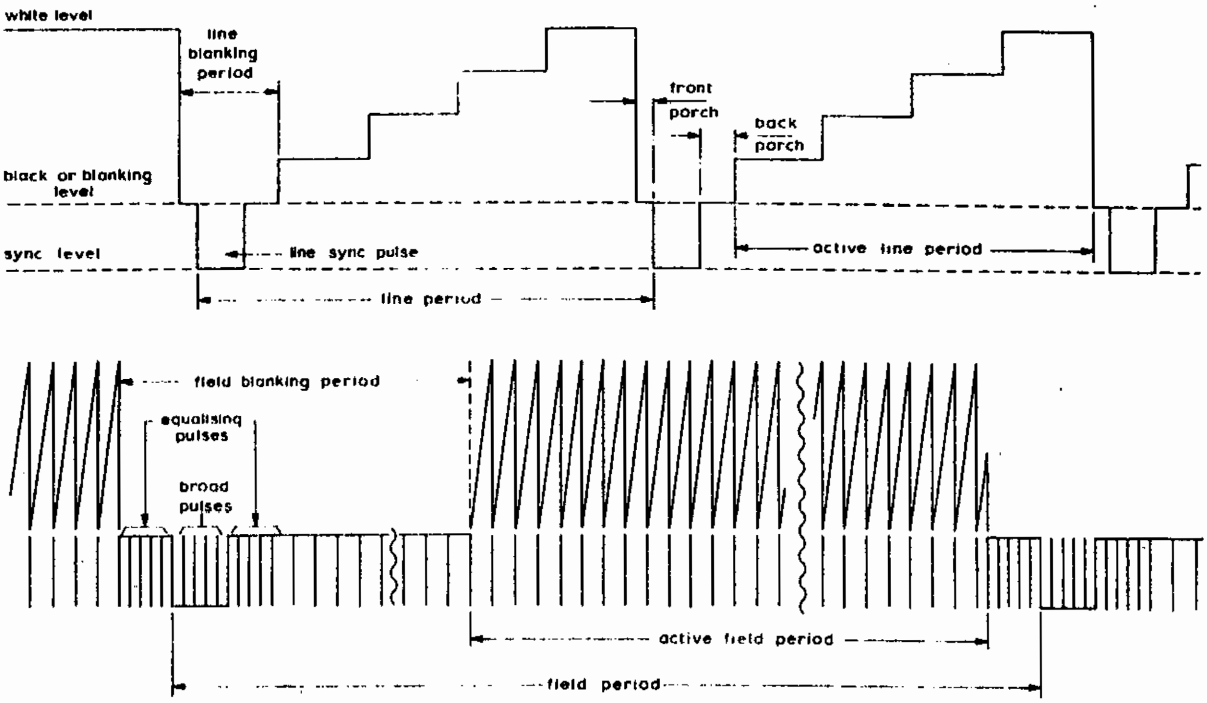
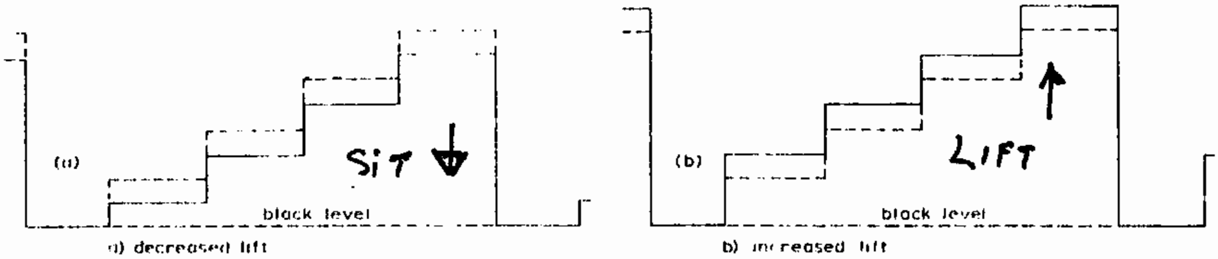


Figure 2.19

2.4.2 Lift

LIFT is another term used in television. The Lift control on a camera alters the level of the minimum brightness in a scene, it can raise or lower the minimum picture signal level. Effectively it adds or subtracts a d.c. signal to the picture signal. The addition of a +ve d.c. is called LIFT, the addition of a - ve d.c. is called SIT.
The figure below shows the picture signals of the simple four-band scene mentioned previously with two types of lift applied.



a) decreased lift

b) increased lift

Figure 2.20 Picture signal of test pattern shown previously with different amounts of lift (original signal shown dotted)

Figure 2.21 shows the video waveform of a general scene to which a small amount of lift has been added.

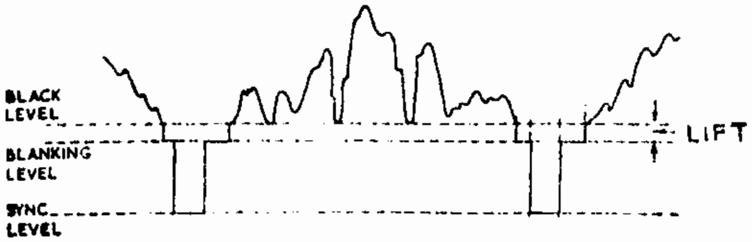


Figure 2.21

The effect of LIFT on a waveform can be seen by doing the GAMMA demonstration but just going as far as operating the LIFT control.

2.4.3 Standard Video Level

To facilitate measurement and standardise equipment there is a STANDARD VIDEO LEVEL. This is lv peak to peak, that is one volt measured from peak white to the bottom of syncs. The ratio of picture signal amplitude to sync pulse amplitude is fixed at 70:30. That is 0.7v from black level to peak white and 0.3v from black level to sync pulse tips, for a lv standard video level signal.

Most video equipment outputs are arranged to give lv p-p into 75Ω but even where it is not, the ratio of 70:30 is maintained.

2.4.4 Picture-Sync Ratio

The only circumstances where 70:30 ratio does not apply is in special circuits used in processing, e.g. sync separation, pre-distortion in transmitters. The ratio 70:30 was selected because of conditions appertaining to the signal received from a transmitter.

Remember that the video signal has two parts, a picture signal and a synchronising signal, can you state why this ratio was selected, rather than say 60:40 or 80:20?

Write your statements in the space below.

As the receiving point moves further away from the transmitter so the received signal strength falls, and the noise level rises. At some point the noise level is such that the picture is not considered viewable. Also, at some point the synchronisation fails.

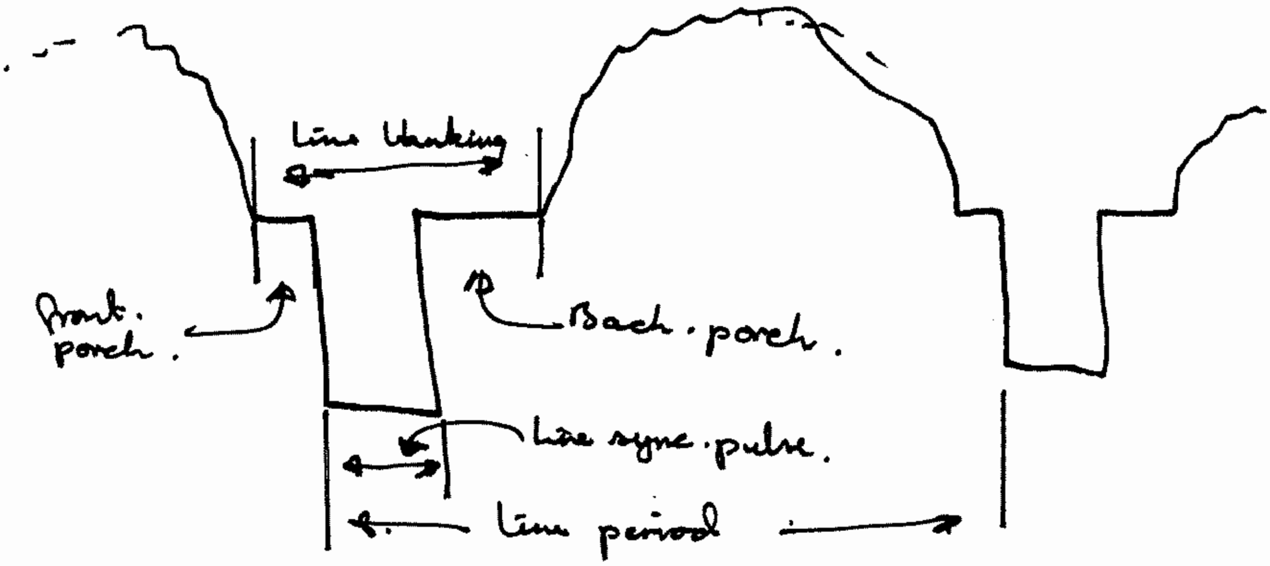
With a 70:30 ratio, the two conditions are reached simultaneously.

If at this point the ratio was 80:20, the picture would still be considered reasonable but synchronisation would be impossible; similarly, if 60:40 were used, the set would lock adequately but the picture would be much too noisy to be of any value.

2.4.5 Characteristics of the U.K. 625-line system

Complete the table below and sketch one line of a video signal identifying relevant parts and amplitudes.

Line Period 64µs.
Line Blanking 12µs (
Front Porch 1:55µs.
Line Sync Pulse 4:7µs.
Field Period 20 ms.
Field Blanking 25H + line blanking
Equalising Pulse 2:3µs (½ line sync period).
Broad Pulse separation 4:7µs.
The timing reference point for line functions is -ve of line sync.
A field starts at the start of the first broad pulse
Field Blanking starts At the beginning of the first equalising pulse.



Line Period	64µs
Line Blanking	12.05 > 0.25µs
Front Porch	1.55 > 0.25µs
Line Sync Pulse	4.7 > 0.1µs
Field Period	20ms
Field Blanking	25 lines + 12.05µs (1 period of line blanking)
Equalising Pulse	2.35 > 0.1µs
Broad Pulse separation	4.7µs > 0.1µs

The timing reference point for line functions is the leading edge of the sync pulse.

A field starts at the leading edge of the first broad pulse.

See figure below.

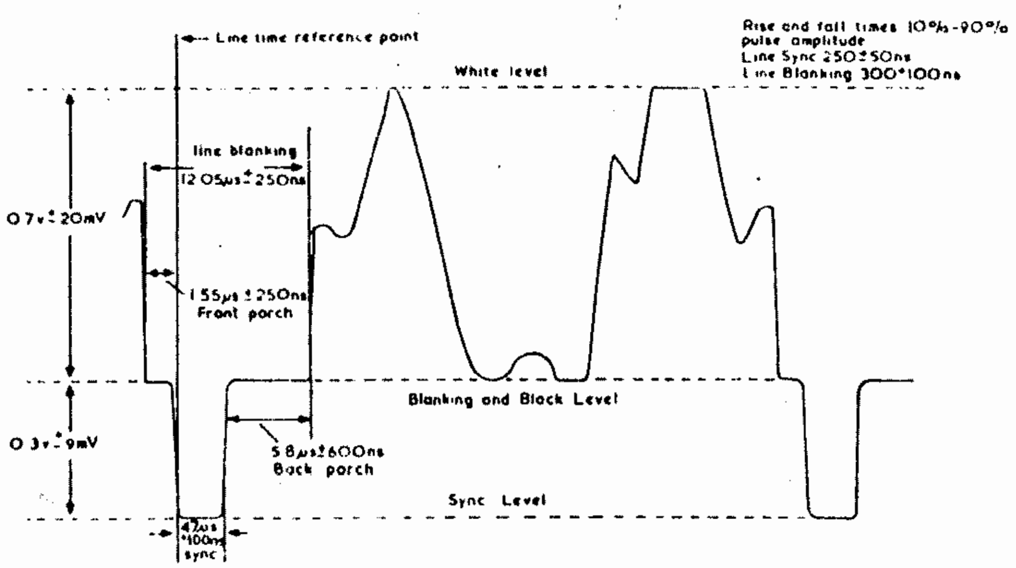


Figure 2.22

NOTE

Pulse duration is measured at half amplitude points. Blanking duration is measured at half amplitude points with a white level signal of line duration.

2.5 LINE STANDARD

2.5.1 General

This is the name given to the number of lines used in a television system. Many different line standards are in use throughout the world. What factors do you think have to be considered in the choice of line standard? See how many you think of bearing in mind that most are based on physiological reasons before carrying on to the next paragraph.- Remember that the object is to display a picture without being aware of its construction, that is you really do not want to see the line structure. The factors to be considered are:-

a) screen size

b) viewing distance

c) visual acuity

d) lighting conditions

e) bandwidth

a) The larger the screen the more lines that will be required.

b) The further the viewing position is away from the screen, the more difficult it is to resolve the line structure. This is associated with (c).

c) Visual acuity is the ability to resolve two fine objects. The criterion is the angle α that the two objects form with the eye.

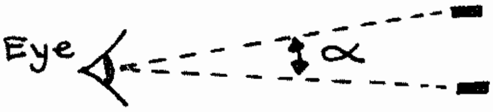


Figure 2.23

The minimum angle required to visually separate the two objects is typically about 1 minute. This will vary from one individual to another.

d) The less ambient light there is the greater is the ability of the eye to see the line structure.

e) The required bandwidth increases with increase in the number of lines used.

Ergonomic tests have been conducted under various conditions and, by many organisations, to ascertain the practical limits. It was discovered that viewers tended to sit at a distance of approximately 8 times the screen height from the screen. The results also suggested that the maximum number of lines that could be resolved at the "normal" viewing distance was about 425. However, the number of lines that need be transmitted is greater than this because the position of horizontal lines in an image may not be coincident with the raster and thus definition is lost. This condition is discussed fully in the paragraph on vertical resolution when bandwidth is being considered.

Time is needed for field flyback, this results in lines not being available for picture information. The number of lines finally chosen controls the line frequency. If the value of line frequency is a product of simple numbers then it eases the generation problem.

The general result is that the number of lines required is between 400 and 800.

2.5.2BANDWIDTH

2.5.2a General

When bandwidth is considered, it is normal to add the constraint of 'bandwidth for equal Horizontal and Vertical resolution.'

2.5.2b Horizontal Resolution.

This is the ability to reproduce abrupt changes in tonal value occuring along horizontal lines. In other words, it measures the sharpness of reproduction of vertical edges.

The scene that requires the highest frequency is one in which a row of elements are alternatively black and white. Ideally a rectangular waveform depicts the scene; however, in practice it has been found reasonable to assume a sinewave shape whose frequency is given by the reciprocal of the time for two elements. The higher the frequency available the smaller each element could be and hence the greater the horizontal resolution. Conversely, as the maximum frequency available is reduced so the horizontal resolution is reduced.

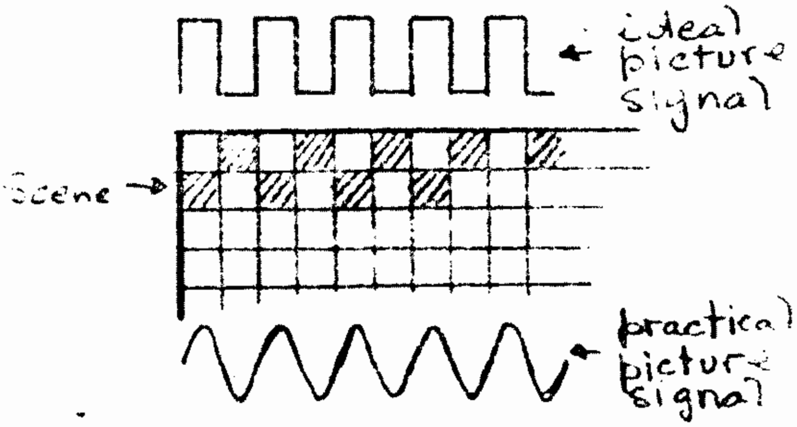


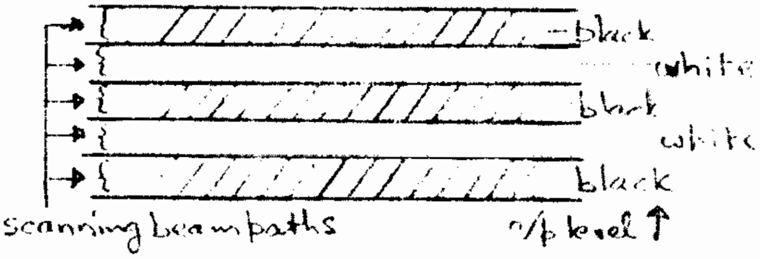
Figure 2.24 Picture signal from alternate black and white elements

2.5.2c Vertical Resolution.

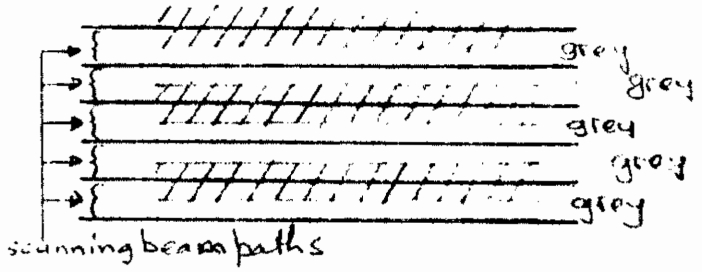
This depends on two factors. The first is the number of lines, the more lines there are in a system the greater is the resolution. The vertical resolution also depends on the positions of horizontal edges of a scene as focussed on to the target of the camera relative to the lines of the raster as laid down on the target. If the relative positions are such that the scanning beam in one line travels along the centre of a row of black elements (say at the bottom of a black horizontal bar) and on the next line travels along the centre of a white row of elements the resolution is perfect. If. however, the beam falls half on the last row of black elements and half on the white elements in the row below, the output is seen as grey and the vertical resolution is reduced. That is instead of going from black to white in one step, it goes from black to grey and then grey to white.

If the viewed scene consists of black and white horizontal bars which when focussed onto the target are the same height as a line of the raster, then if the displacement is 50% of the height of a line the output is always grey and the resolution is zero.
The figure below depicts various conditions.

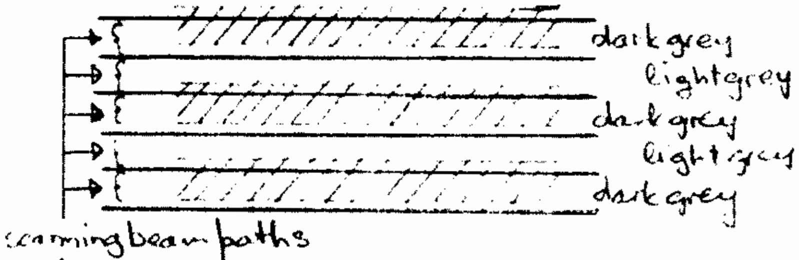
Co-incident focussing on the camera target. This results in perfect vertical resolution.



50% displacement rsults in zero vertical resolution.



Less than 50% displacement results in less than perfect vertical resolution.



A 3-line black horzontal bar on a white background focussed onto a camera target such that there is a slight displacement of the edge of the bar and the raster lines. This prevents instantaneous transitions from black to white.

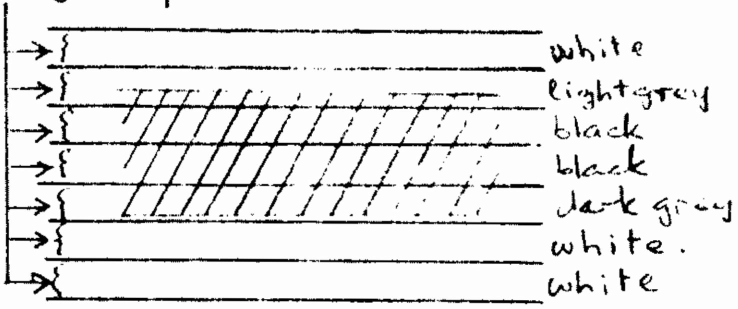


Figure 2.25 Relative positions of raster and scene horizontal information

2.5.3 Bandwidth Calculation

Let W = horizontal dimension of the raster.

Let h = vertical dimension of the raster.

Assume square elements.

Let N_T = total number of lines in the system.

Let N_A = number of active lines.

Let N_{FB} = number of lines in field blanking.

$$N_A = N_T - N_{FB}$$

Vertical dimension of an element $= \dfrac{h}{N_A} = \dfrac{h}{N_T - N_{FB}}$

Because the elements are square :-

the number of elements in a row $= \dfrac{W}{h \div (N_T - N_{FB})} = \dfrac{W}{h} . (N_T - N_{FB})$

Aspect Ratio $= a = \dfrac{W}{h}$

Therefore, the number of elements in a row $= a(N_T - N_{FB})$

Maximum frequency occurs when alternate elements in a row are black and white.

Therefore, the number of cycles in a row $= \dfrac{a(N_T - N_{FB})}{2}$

These occur during the active line time.

Let L_A = active line time.

Then the maximum frequency $= \dfrac{a(N_T - N_{FB})}{2.L_A}$

Let L_T = total line time.

Let L_B = line blanking.

Therefore, maximum frequency $= \dfrac{a(N_T - N_{FB})}{2(L_T - L_B)}$

For the 405-line system ;-

$N_T = 405$, $N_{FB} = 28$ (14 lines per field), $L_T = 98.7$ µs, $L_B = 18$ µs,

$a = 4/3$.

$$\text{Maximum frequency} = \frac{4/3(405 - 28)}{2(98.7 - 18) \times 10^{-6}} \text{ Hz}$$

$$= \frac{2}{3} \times \frac{377}{80.7} \text{ MHz} = 3.11 \text{ MHz.}$$

Calculate the maximum frequency for the 625-line system.

Blanked lines = 25 per field = 50 per picture.

Line Blanking = 12μs. Line time = 64μs

Aspect Ratio = 4/3

$$f = \frac{4/3.(625-50)}{2.(64-12).10^{-6}} = \frac{2}{3} . \frac{575}{52}\ \text{MHz} = 7.37\ \text{MHz}$$

If you have any previous knowledge of television, you will realise that this figure is much higher than you expect.

The reason for this discrepancy is connected with the criterion of equal horizontal and vertical resolution. With vertical resolution, the ideal situation only occurs when the horizontal lines in an image fall coincidently on the horizontal lines of the raster. In most instances this does not occur and the vertical resolution is less than ideal, as therefore is the total resolution. This led to the suggestion that it was not necessary to maintain the horizontal resolution at its theoretical maximum. Practically, this meant that the maximum frequency of the transmission system need not be as high as the theoretical maximum.

Once again many tests were carried out to assess how much the bandwidth could be reduced and still maintain acceptable resolution. The object was to produce a factor by which the theoretical bandwidth could be modified to give a practical bandwidth. This is called the KELL factor. Various values from about 0.53 to 0.85 have been suggested, a value of about 0.7 is generally accepted. This figure is still the subject of debate and many values are used. In the U.K. 405-line system a KELL factor of unity is used.

SECTION 3

VIDEO SIGNAL PROCESSING TECHNIQUES

SECTION 3 MISCELLANEOUS VIDEO SIGNAL PROCESSING TECHNIQUES

3.1 GAMMA

3.1.1 Picture tube non-linearity

Ideally, individual items of equipment in the television chain should have linear input/output transfer characteristics. This should apply whether the input and output are electronic signals, light signals or transposing from one to the other. Most amplifiers can be made to be linear, the camera light input to electrical output transposition in modern cameras is substantially linear, but the picture tube transfer characteristic is inherently non-linear. In other words, doubling the electronic signal input does not double the light output. The actual characteristic is of the form shown in Figure 3.1.

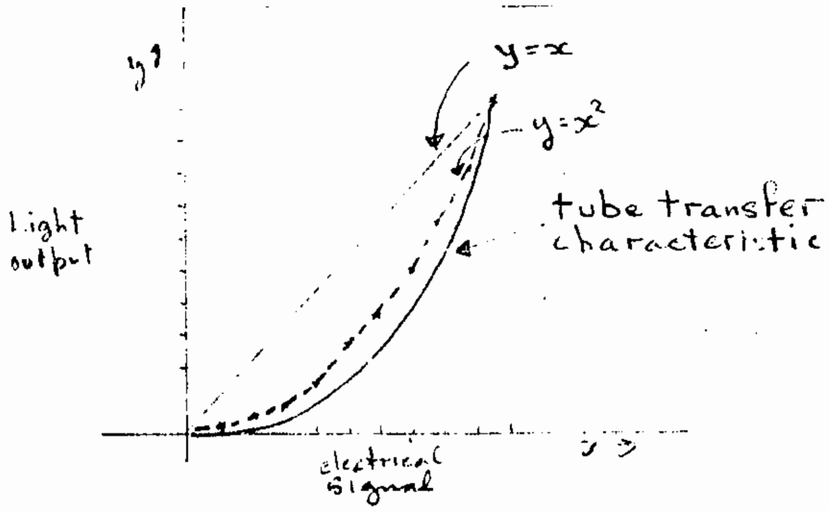


Figure 3.1 Picture tube transfer characteristic

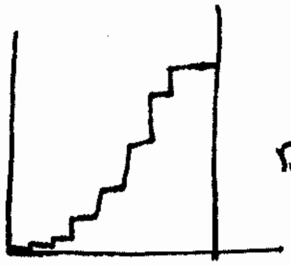
In this drawing, the straight line depicts the ideal linear relationship, the dotted curved line is the graph of the output when it is the square of the input. The full curve typifies the actual input/output relationship of a picture tube. The shape indicates that the output is the input raised to some power which is greater than 2, that is the square of the input. The power to which the input is raised is called 'gamma' and is denoted by the greek symbol γ.

For monochrome tubes gamma ≈ 2.2.

For colour tubes gamma ≈ 2.8. [2.6 to 2.8]

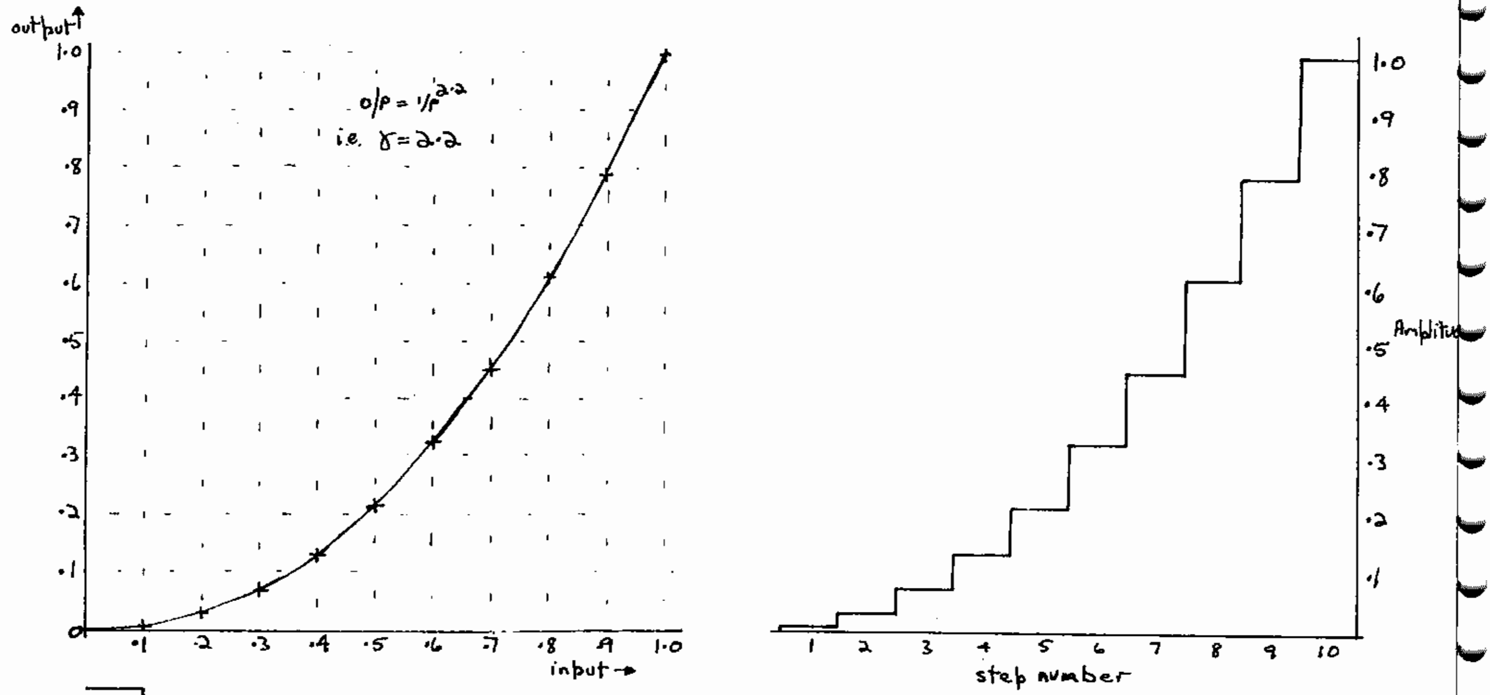
What effect will tube gamma have on a linear signal - say a staircase with many equal steps?

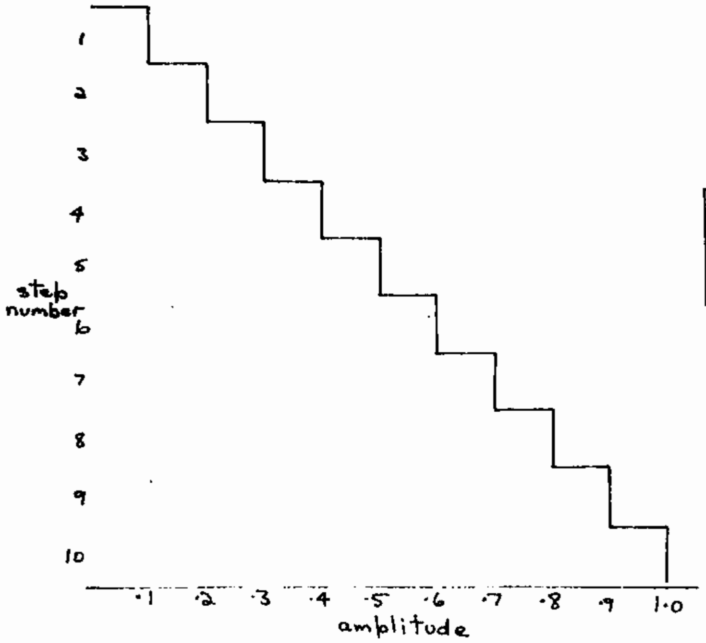
Sketch the output waveform.



Black level Crushing occurs.

Figure 3.2 shows a transfer characteristic where o/p = $(\mathrm{i/p})^{2\cdot 2}$, that is for a monochrome tube. If a linear 10 step staircase is applied the drawing shows that levels near to black are crushed and levels near to white are stretched.





i/p	·1	·2	·3	·4	·5	·6	·7	·8	·9	1·0
o/p $[\mathrm{i/p}^{2\cdot 2}]$	·006	·029	·071	·133	·218	·325	·456	·612	·793	1·0

Figure 3.2 Linear staircase applied to non-linear circuit

Question: How can this problem be overcome?

Answer: By passing the signal through a amplifier with a non linear transfer characteristic which is equal in but opposite in sense of the Non Linear transfer Characteristic of the tube.

3.1.2 Gamma Correction

The electrical signal is deliberately distorted in such a way that, after passing through the distorting circuit and the tube, the camera input to tube output is a linear relationship. When a signal is deliberately distorted to overcome some inherent distortion the process is called PRE-DISTORTION. This particular pre-distortion process is called GAMMA CORRECTION. Sketch the shape of the transfer characteristic of the gamma corrector on the figure below.

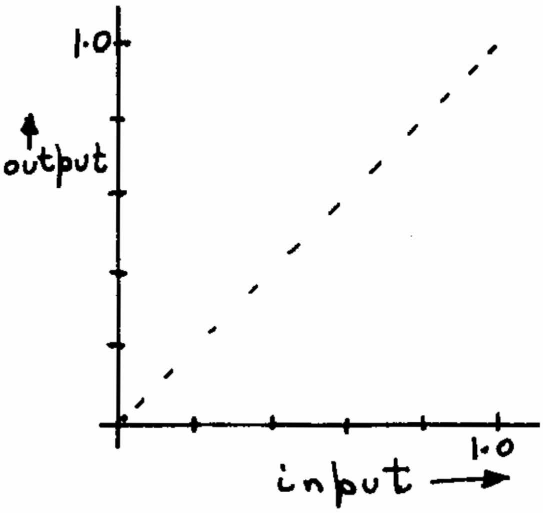


Figure 3.3 Estimated shape of a Gamma Corrector reponse

Question: What is the form of the mathematical relationship between the input and output of the Gamma Correction unit? A general, not a precise form is required.

Answer: Square Law.

$\gamma = 2{\cdot}5$ $\cdot 1^{2\cdot5}$ ·003 ·6021

$\cdot 07^{2\cdot5}$ $\cdot 2^{2\cdot5}$. ·017. ·0119

·1

·2

·3

Figure 3.4 shows the shape of the required gamma corrector transfer characteristic.

The formule relating input and output of the gamma corrector is of the form o/p = (i/p) raised to the power x, where x is <1.

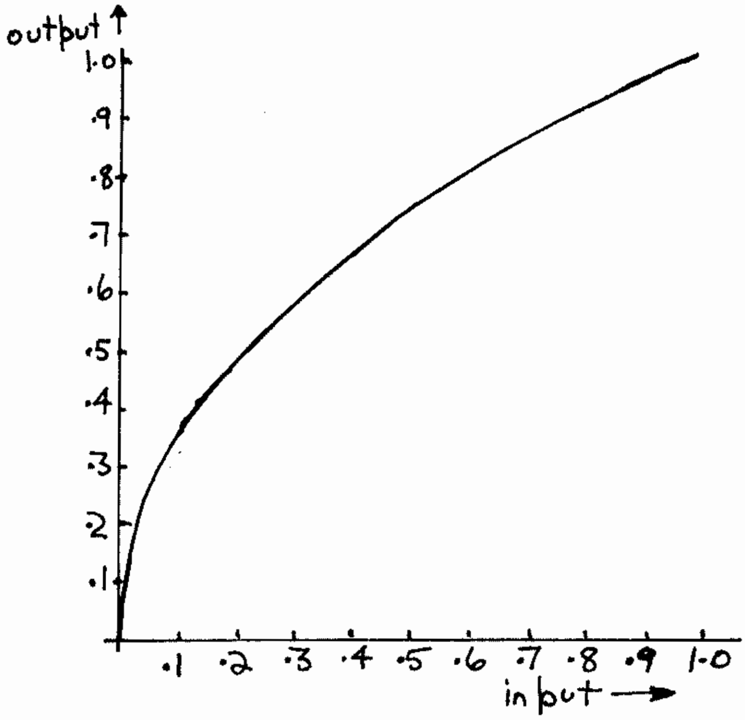


Figure 3.4 Gamma Corrector Characteristic

Go to the demonstration equipment and do the Gamma demonstration.

GAMMA CORRECTION CALCULATION

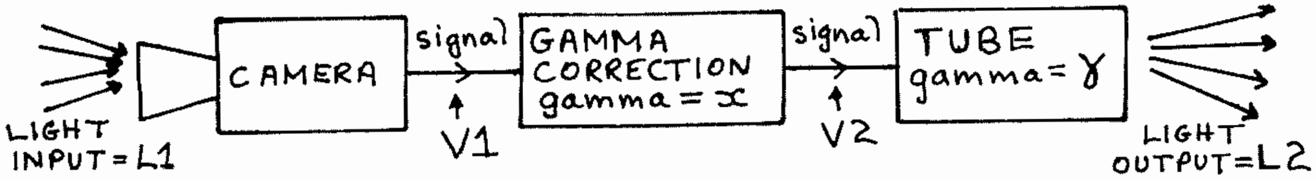


Figure 3.5

Let: the light input to the camera = L1

the signal out of the camera = V1

the signal out of the gamma corrector = V2

the light output of the picture tube = L2

Because of tube non-linearity $L2 = (V2)^{\gamma}$ ....(1)

$L1 = V1$ (Camera substantially linear)

$V2 = (V1)^{x}$......... (2)

Substituting (2) in (1)

$L2 = [(V1)^{x}]^{\gamma} = (V1)^{x.\gamma} = (L1)^{x.\gamma}$

For correct predistortion $L2 = L1$

Therefore, $x.\gamma = 1$

Therefore, $x = 1/\gamma$

for $\gamma = 2.2$ $x = 1/2.2 = 0.45$

In practice the correction circuit is said to have a gamma of 0.45. For colour tubes the correcting gamma = 1/2.8 = 0.36.

3.1.3 Gamma Corrector Unit Position in the Transmission Chain

Having decided on the amount of pre-correction, the problem is where to apply it.

There are two positions to consider, at the origin, e.g. the camera, or in each receiver (or picture monitor).

What are the advantages and disadvantages of having the gamma corrector at the different positions? List them!

First considerations:-

a. Camera. Only one gamma correction unit is needed. However, will the pre-distortion unit gamma match the gamma of all the display tubes? If not, the overall characteristic will not be linear. Is the gamma of mass-produced tubes consistantly the same?

b. Receiver (display unit). One needed for every tube. Each tube could be exactly matched but perhaps every set would have to be individually adjusted.

In fact the transfer characteristics of tubes are reasonably predictable in manufacture and are fairly similar. This means that individual correctors are not essential and it is valid to have one gamma corrector at the studio thus making a great overall financial saving.

There is, however, a strong technical argument for having the gamma corrector at the programme source.

Consider again a linear staircase waveform corresponding to the output of a camera focussed onto a scene consisting of say 10 vertical bands going from black to white in equal steps from left to right. Noise is inevitably added to the signal during distribution and will be of the same amplitude on all of the steps of the waveform. If the gamma corrector was sited in the receiver, the combination of pre-correction and tube gamma would result in equal noise amplitudes on each of the steps. With equal noise amplitudes on each step the signal to noise ratio is worse on the low level steps than on the high level steps, the noise is the same but the signal levels are different. The result is that the noise appears much more objectionable in dark areas than in light areas of the scene.

Now consider the situation when the gamma corrector is sited at the studio. Along the transmission chain the staircase does not have linear steps. The lower level steps are stretched and the higher level ones are crushed. As in the previous instance, after distribution, the induced noise is of equal amplitude on all the steps. The tube gamma now converts the staircase back to a linear function and the noise amplitudes are now not equal on all the steps. The noise levels on the lower steps have been reduced thus increasing the signal to noise ratio compared to the system with the gamma corrector being mounted immediately before the tube.

These effects are illustrated in Figure 3.6.

In practice, gamma correction is applied at source and results in noise reduction and considerable overall economy.

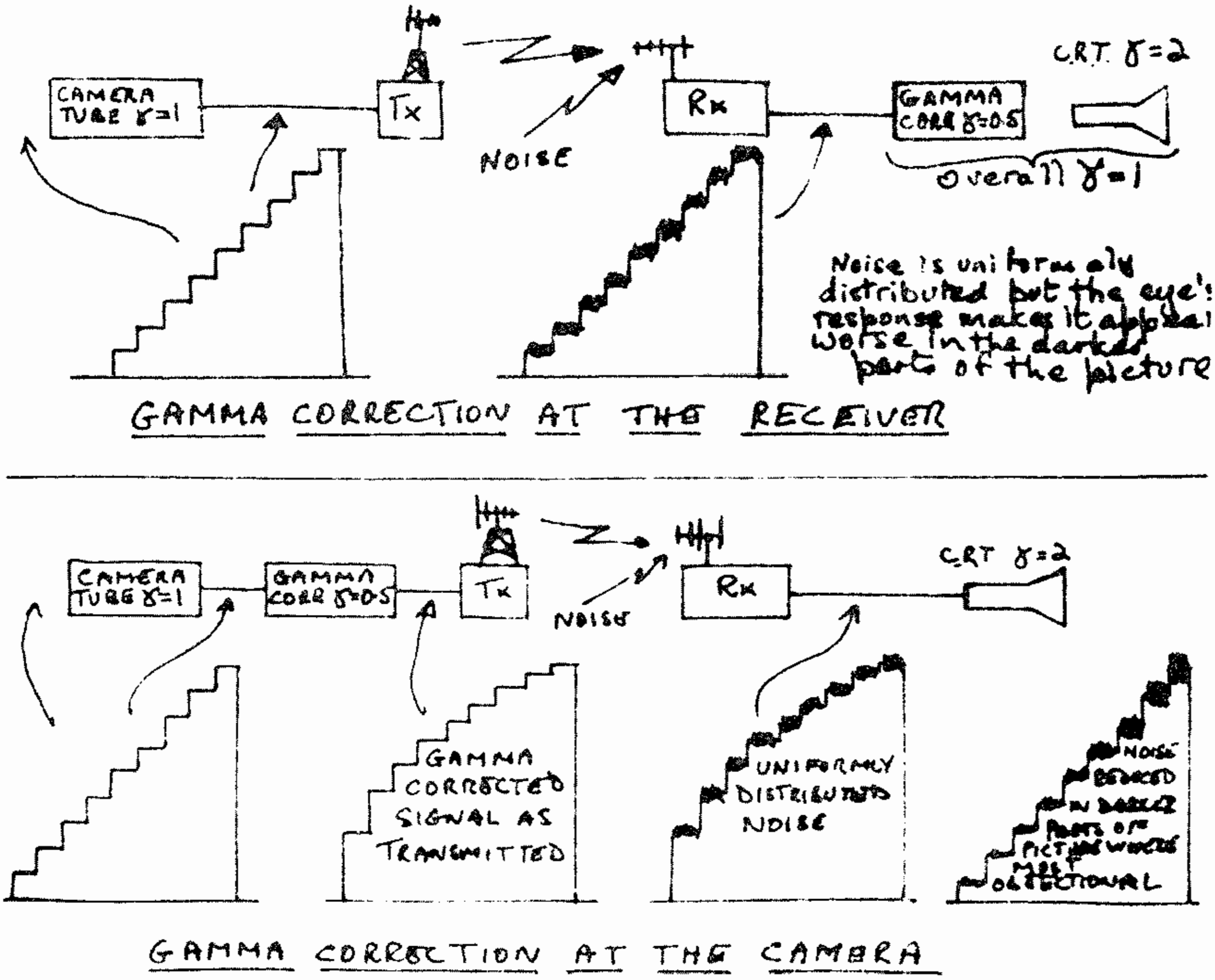

CAMERA TUBE γ=1
Tx
NOISE
Rx
GAMMA CORR γ=0.5
C.R.T. γ=2
Overall γ=1
Noise is uniformly distributed but the eye's response makes it appear worse in the darker parts of the picture
GAMMA CORRECTION AT THE RECEIVER
CAMERA TUBE γ=1
GAMMA CORR γ=0.5
Tx
NOISE
Rx
CRT γ=2
GAMMA CORRECTED SIGNAL AS TRANSMITTED
UNIFORMLY DISTRIBUTED NOISE
NOISE REDUCED IN DARKER PARTS OF PICTURE WHERE MOST OBJECTIONAL
GAMMA CORRECTION AT THE CAMERA

Figure 3.6 Gamma Corrector Position

3.2 RECOVERING THE D.C. COMPONENT

3.2.1 General

The complete video waveform has a d.c. component and an a.c. component. In the distribution chain it is easier to use a.c. coupling techniques which remove the d.c. component. At many points along the chain and in the receiver it is essential that the d.c. component is replaced. This is in order to carry out certain functions, monitoring for example. Before describing these techniques, a revision of a.c. coupling would be useful, particularly with regard to its effect on square waves.

3.2.2 A.C. Coupling

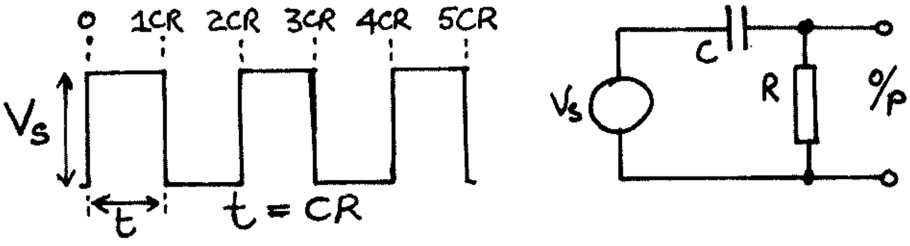


Figure 3.7 A.C. Coupling Circuit

In Figure 3.7 the square wave generator can be considered as a perfect voltage source during the ON period and as a short circuit during the OFF period. The voltage waveform has a 1:1 ON:OFF ratio (also called 1:1 Mark:Space ratio). The capacitor is initially discharged and the ON period has a duration of CR seconds. Consider the waveform of the capacitor voltage over a period of 5 x CR seconds.

At CR seconds Vc = 0.63Vs. Between t = CR and t = 2CR the capacitor discharges and at t = 2CR it has fallen by a value of 0.63 x 0.63Vs Z 0.4Vs. so at this point Vc = (0.63 - 0.4)Vs, Vc = 0.23Vs.

Between 2CR and 3CR the capacitor charges, this time the charging voltage is (Vs - 0.23Vs) = 0.77Vs. The increase in voltage is (0.63 x 0.77Vs) = 0.485Vs, the voltage across C is (0.485 + 0.23)Vs = 0.715Vs. Between 3CR and 4CR, the capacitor voltages fall by (0.63 x 0.715Vs), that is 0.45Vs to (0.715 - 0.45)Vs that is to 0.265Vs. This continues and the sketch of Vc is given in Figure 3.8.

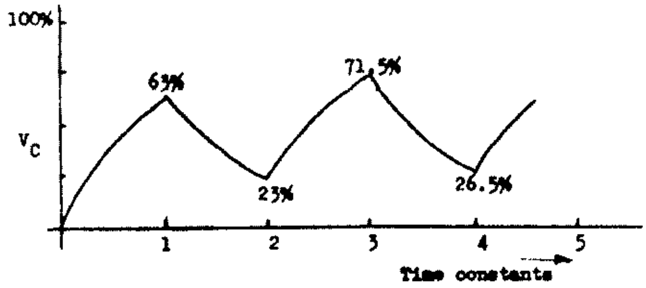


Figure 3.8 Vc, The voltage across the capacitor

The resistor voltage plus the capacitor voltage must always equal the supply voltage. Draw the waveform of the resistor voltage.

Figure 3.9 shows the waveform of VR, the output voltage.

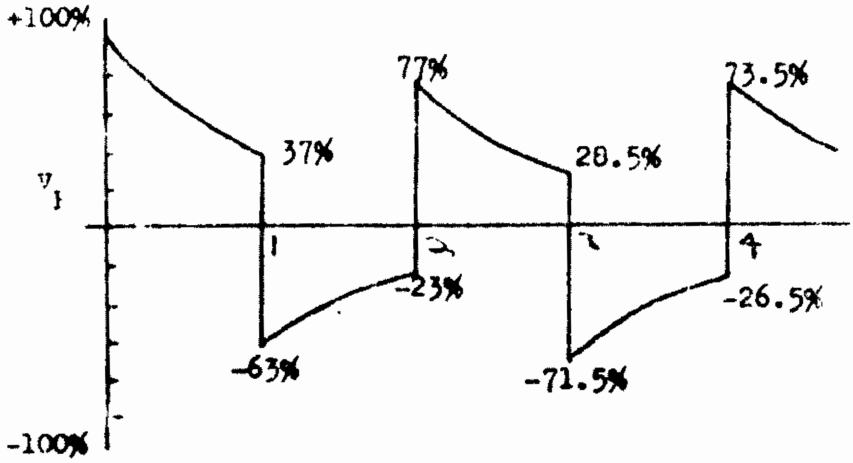


Figure 3.9 Vr. The voltage across the resistor for 0 to 4CR seconds

Each time the supply voltage changes abruptly, the full change appears across the resistor, this is because the capacitor voltage cannot change instantaneously.

After a sufficient time the waveform of the voltages across the capacitor and across the resistor settle down and repeat over each cycle. This gives the same magnitude of aiming voltage for charge and discharge.

Draw Vc and Vr on figure 3.10 showing values.

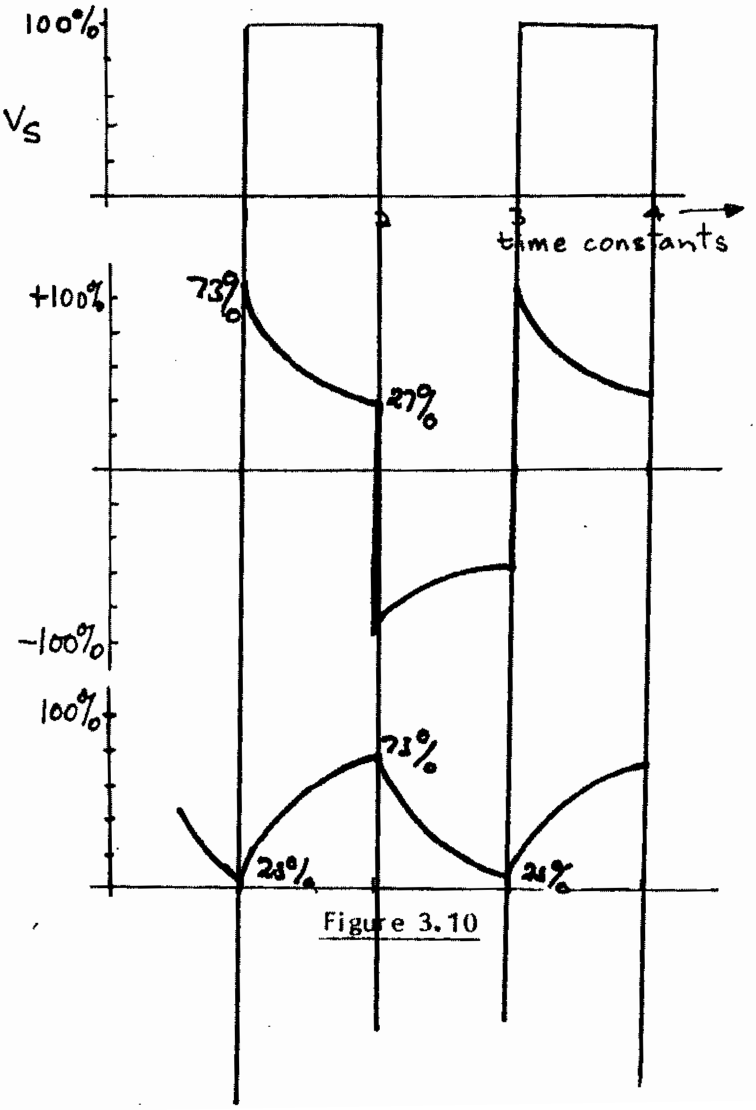


Figure 3.10

Figure 3.11 shows the final form of the waveforms.

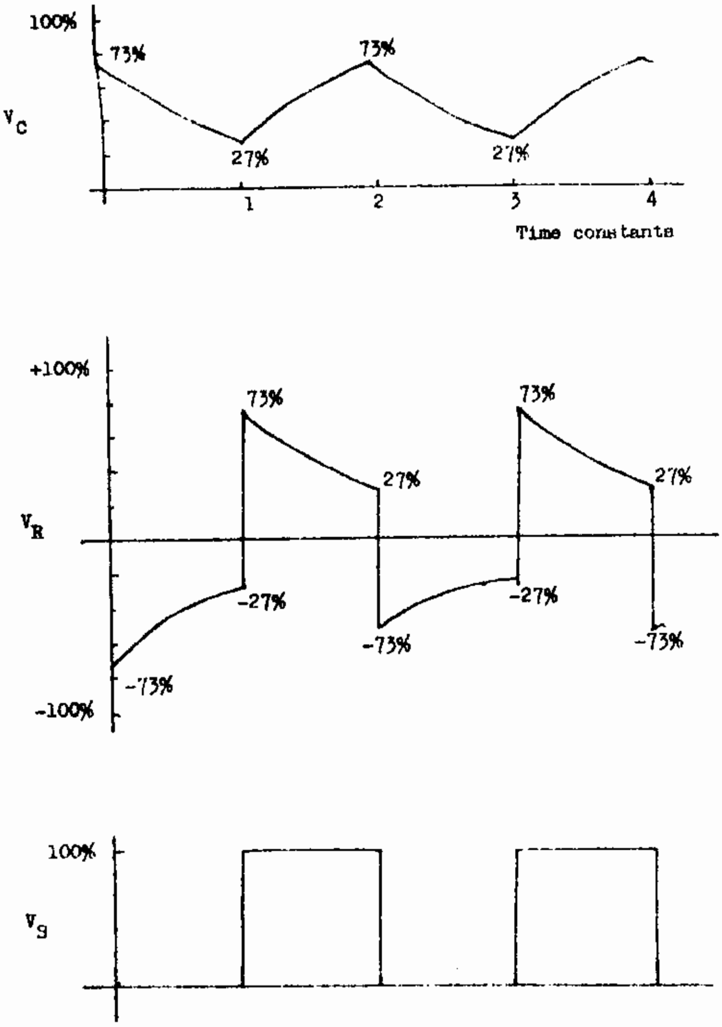


Figure 3.11 Final Waveform for t = CR

If the time constant is increased to 10 times the value previously considered, the waveforms still retain the same basic shape but the value of the excursions is modified. Figure 3.12 shows this condition.

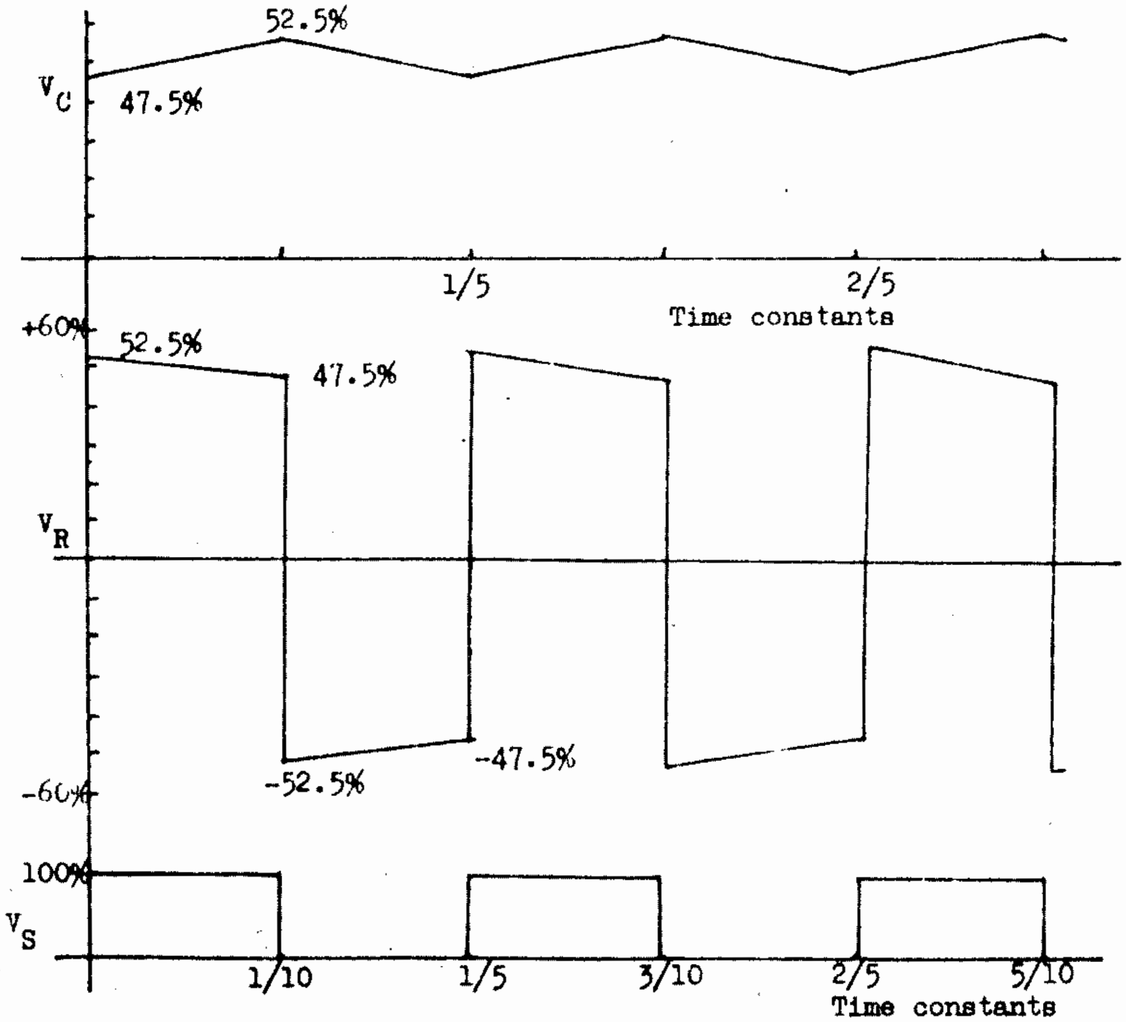


Figure 3.12 Final conditions waveforms for CR = 10t

The sag on the output voltage is reduced and the voltage variation on the capacitor about its average value is reduced.

For the equal M:S ratio waveform under consideration the average value on the capacitor after many cycles is Vs/2 .

Consider the circuit shown in Figure 3.13.

Draw Vs, Vc and Vr when equilibrium is reached.

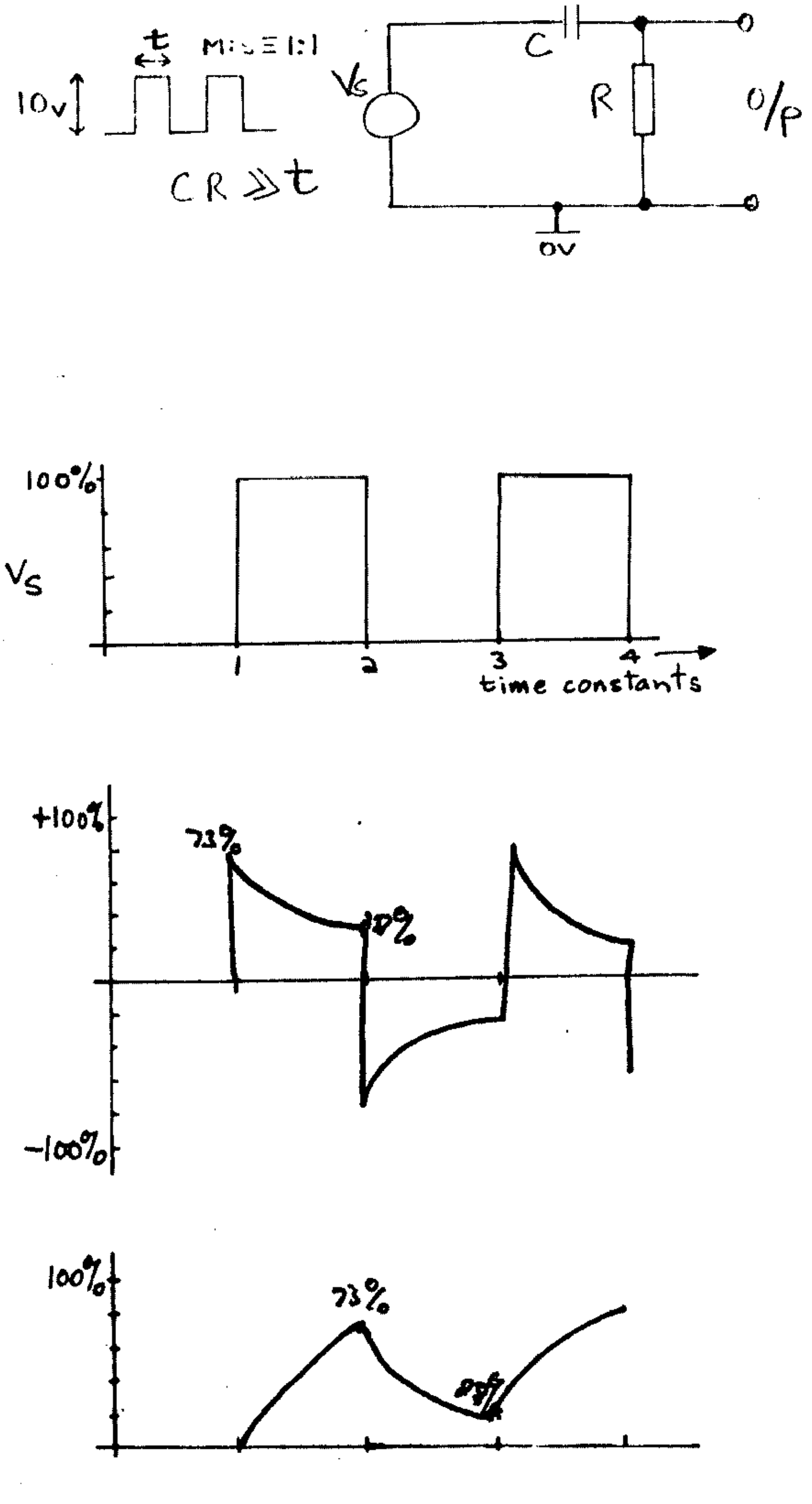


Figure 3.13

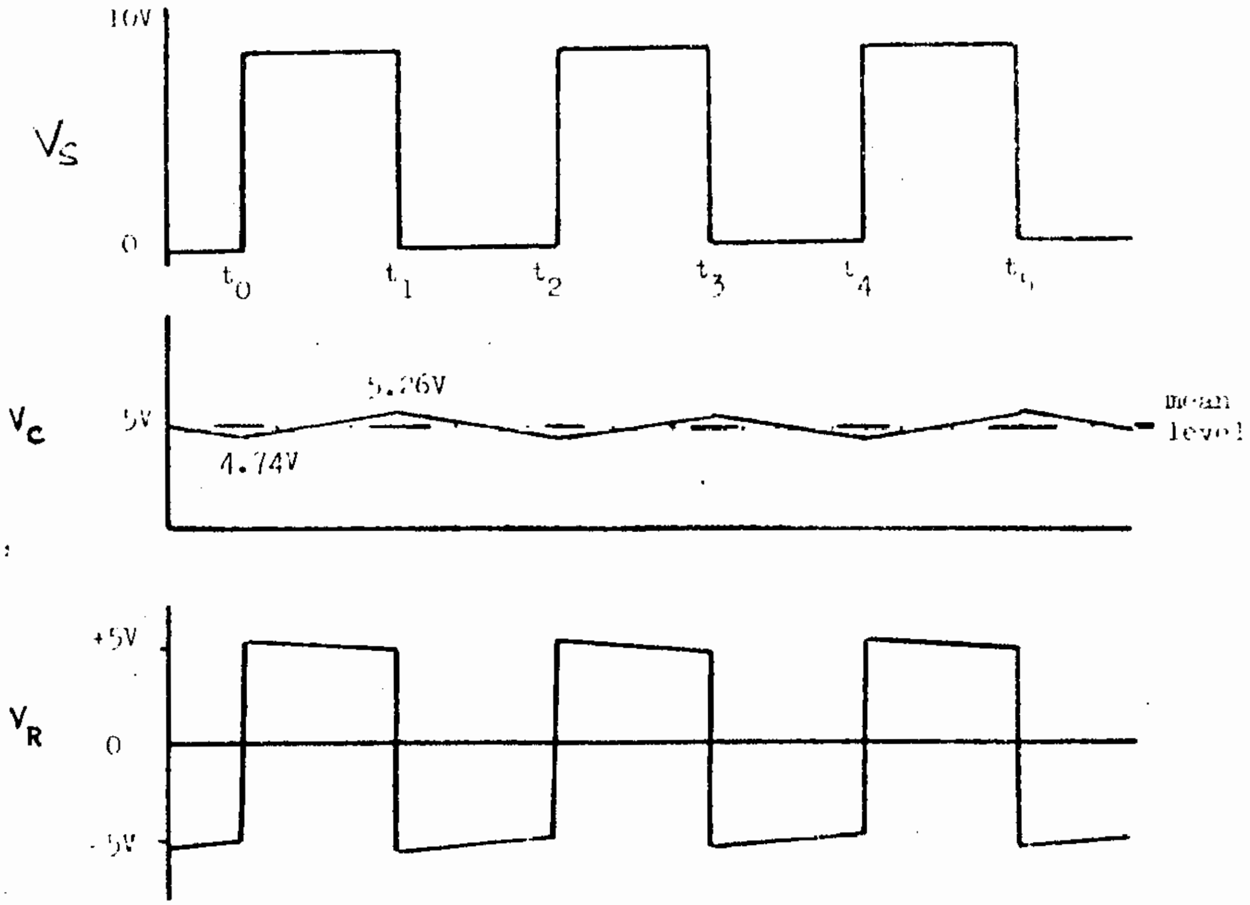


Figure 3.14 Long CR - Steady State Conditions

The output waveform is very nearly the same shape as the input but varies symmetrically about 0V, the common rail potential. The capacitor is charged to +5 volt, the average value of input signal.

A.C. Coupling Conclusion.

The output waveform from a capacitor-resistor coupled circuit sits with its average value at the common rail potential and the capacitor charges to the average value of the applied waveform. To avoid distortion of the applied signal the time constant of the circuit must be long compared to the periodic time of the applied signal.

Now consider the situation when the waveform applied to a CR circuit does not have an equal mark-space ratio. Figure 3.15 shows two such waveforms.

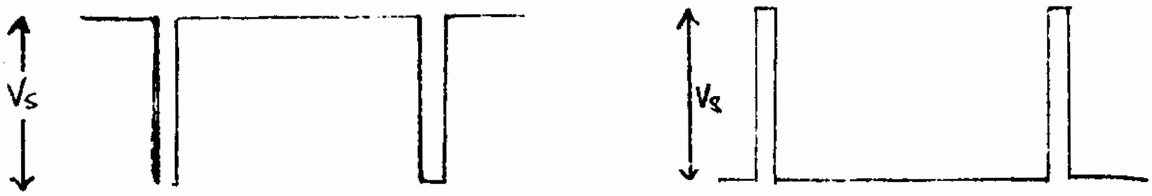


Figure 3.15 Unequal M:S ratio waveforms

Sketch the output waveform for the two conditions.

Figure 3.16 shows the output of an A.C. coupled circuit for two types of unequal M:S ratio waveforms.

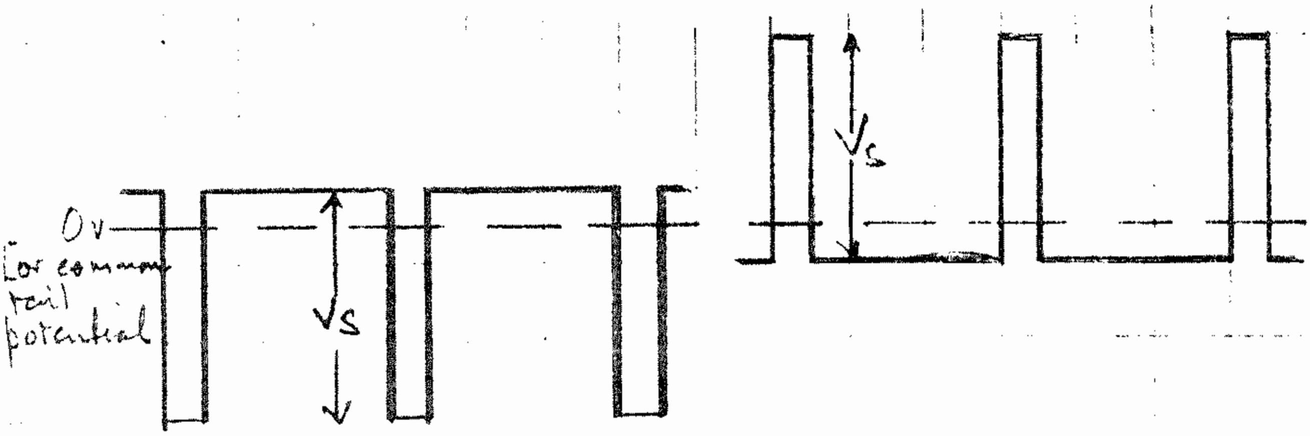


Figure 3.16

EFFECT OF A.C. COUPLING ON A TELEVISION SIGNAL

The complete video signal is applied to the circuits that control the amplitude of the beam current of a C.R.T. The controls are adjusted so that black level potential (and below for a +ve going signal) does not cause any light to be emitted by the phosphors. As the signal increases towards white more electrons are emitted and the phosphors emit the corresponding amounts of light.

With an a.c. coupled signal and of 50% average picture level (A.P.L.), applied to the crt the brightness control is adjusted for correct light emission (or lack of light) at black level. If the scene changes to one in which there is only a small amount of peak white (low A.P.L.), then the level of the peak white signal will be higher than that of peak white for the 50% A.P.L. In this condition black level will also be higher than before and will take up a darkish grey equivalent level. It could well be that before peak white in the low A.P.L. scene is reached the beam current limits.

What would be the effect if there was some detail (variation of level) at or about peak white? Loss of detail.

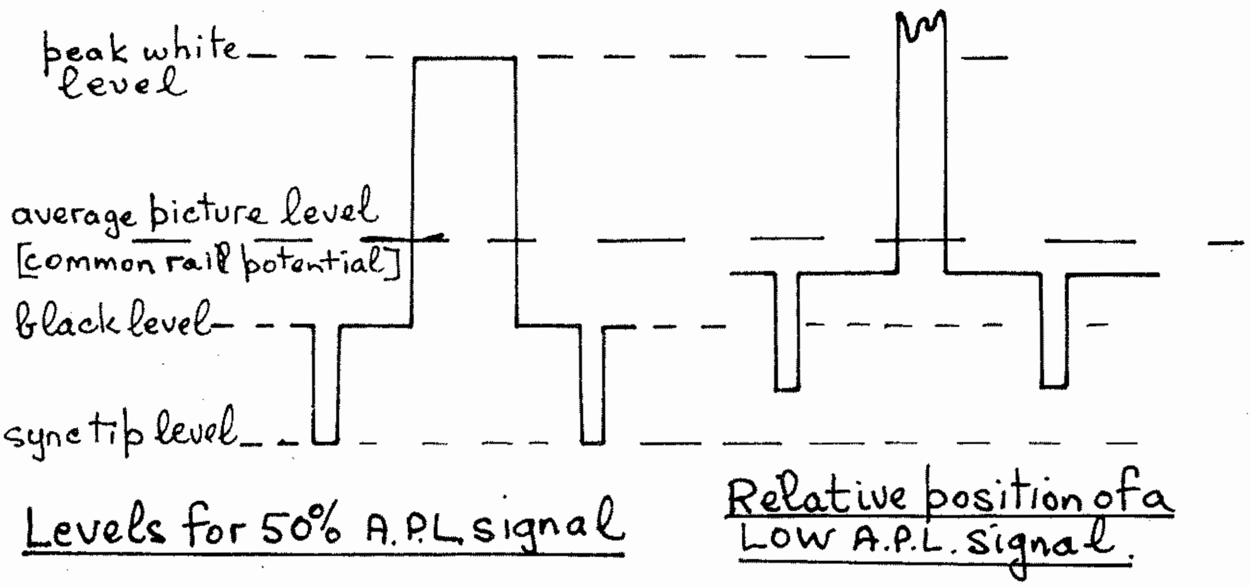


Figure 3.17 High-to-Low A.P.L. Change

Any variation at peak white in the low A.P.L. scene would not be shown because the beam current is limiting.

A signal representing a high A.P.L. is now applied to the tube. Draw the corresponding waveforms and deduce any short coming of the displayed picture.

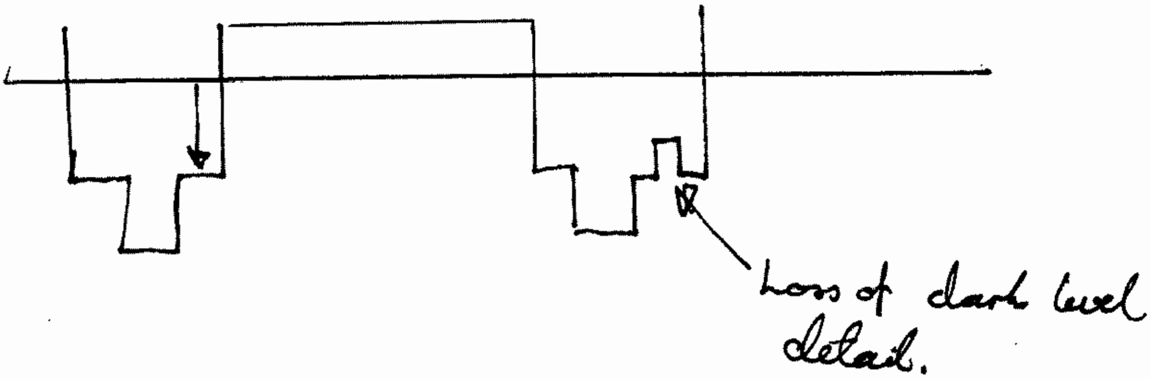


Figure 3.18 shows the waveforms.

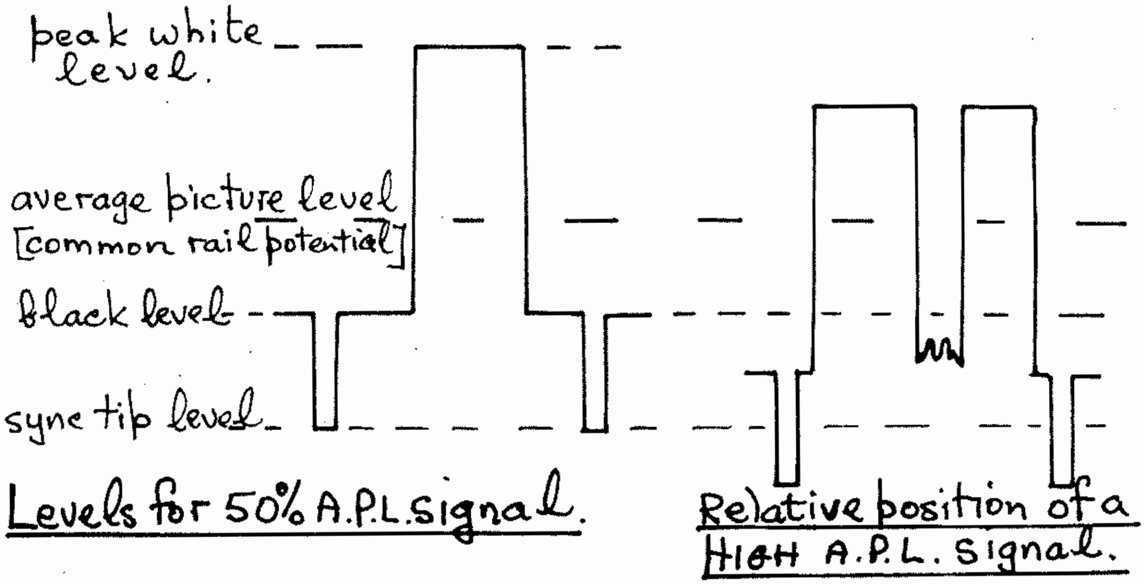

peak white level.
average picture level [common rail potential]
black level
sync tip level
Levels for 50% A.P.L. signal.
Relative position of a HIGH A.P.L. signal.

Figure 3.18 Low-to-High A.P.L. Change.

In these circumstances, detail in the dark areas could be lost because it is below the black level set up for the 50% A.P.L. scene.

The conclusion is that the d.c. component must be restored before the video signal is applied to a monitor tube.

SOLUTION

Picture amplitude varies, sync pulse amplitude does not, or should not, therefore by using the sync pulse as a reference in some way there is a fixed point no matter how the picture signal is varying. Either black level as provided at the back porch or sync tips could be used.

Go to demonstration equipment and complete the AC Coupling demonstration.

3.3 D.C. RESTORATION

This technique uses sync tips as the reference.

Simple Version. A circuit rather like an a.c. coupling circuit is used but the resistor is replaced by a diode. The configuration is shown in Figure 3.19.

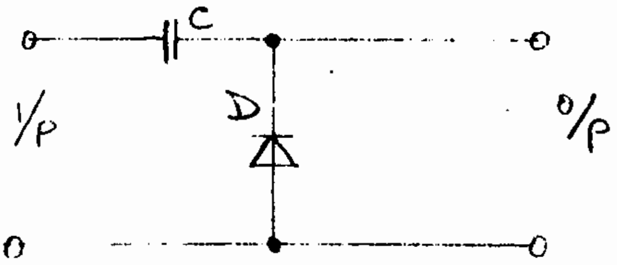


Figure 3.19 Simplified D.C. Restorer Circuit

Initially the capacitor is discharged, and an a.c. coupled video signal is applied to the circuit, see Figure 3.20. For ease of explanation it is assumed that the common rail is at earth potential and the circuit connected to the output has a high input impedance.

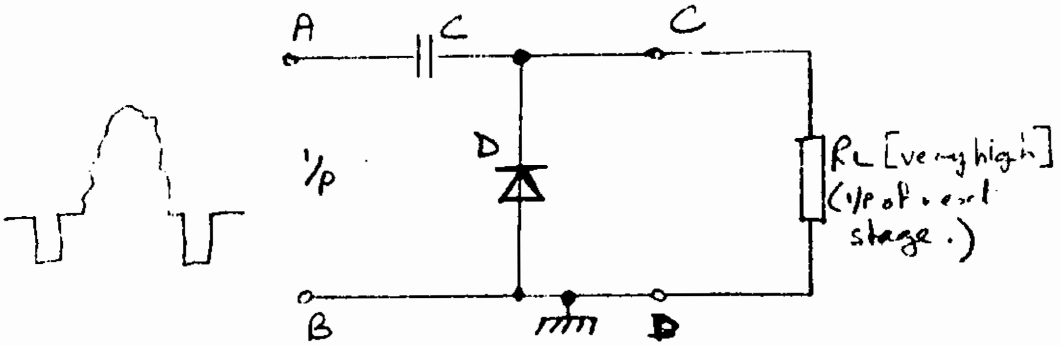


Figure 3.20

If point A goes positive w.r.t. point B the diode does not conduct and because the impedance (RL) across CB is high the capacitor will not charge very much and the input change at AB appears at CD.

When the input signal takes point A negative w.r.t. point B then the diode conducts and is effectively a very low resistance. This holds point C at earth potential. The capacitor now charges until the input signal goes positive, or until it has changed to the value of the negative transition.

The capacitor acquires a voltage such that the plate connected to A is negative w.r.t. point B. Because of the high impedance of the circuit connected to CB the capacitor retains almost all of its charge. This means that when the input signal goes negative again the diode will not conduct until the input is more negative than the voltage on the capacitor.

If this point is reached, the diode again conducts and charges the capacitor to a yet higher voltage.

This continues until the diode conducts on the most negative part of the waveform, i.e. on sync tips only.

The output waveform now has sync tips fixed at earth potential and the signal level variation is unipolar, that is in one direction only from sync tips.

The d.c. component has been restored. The voltage to which the capacitor has charged is the mean d.c. level of the signal.

Effects of variation of picture signal.

If the signal applied to the circuit is changed to one having a High A.P.L. what is the effect on the circuit in which the capacitor is already charged to the mean level of a 50% A.P.L. signal?

The sync tips of the High A.P.L. signal are more negative w.r.t. the mean level than in the previous instance. This means that for the period of sync tips the diode conducts and charges the capacitor. Again, at the output, sync tips are held to earth. Peak white is a fixed level w.r.t. sync tips, lv for a standard video level signal. This means that if the sync tips of both a 50% A.P.L. signal and a High A.P.L. signal are fixed at the same potential, earth in the examples, then the black levels of both signals are at the same potential and the white levels are at the same potential. The d.c. restorer circuit just discussed holds sync tips at earth potential. In practice, it holds them to whatever potential the anode of the diode is connected.

What is the effect if the 50% A.P.L. signal was changed to a Low A.P.L. instead of a High A.P.L.?

Because of the a.c. coupling, the input signals sits with its mean level at the common rail potential of the previous circuit. The sync tip level is now at a higher potential (more positive) than in the previous instance. This means that sync tips do not drive the diode into conduction and sync tips are not fixed at earth potential. This is the disadvantage of a simple D.C. restorer circuit, it cannot handle rapid decreases in A.P.L. To cope with this situation, the capacitor would have to discharge during the picture period of the line. This can be achieved by connecting a resistor across the diode. Figure 3.21 shows the circuit. The value of the resistor has to be low enough to discharge the capacitor quickly to cope with changes in the A.P.L. What would be the effect on the video signal if a constant level signal was present?

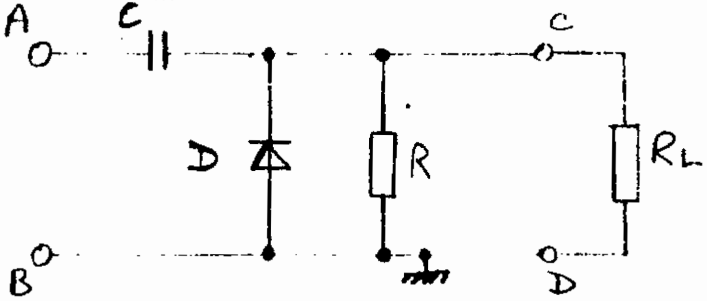


Figure 3.21

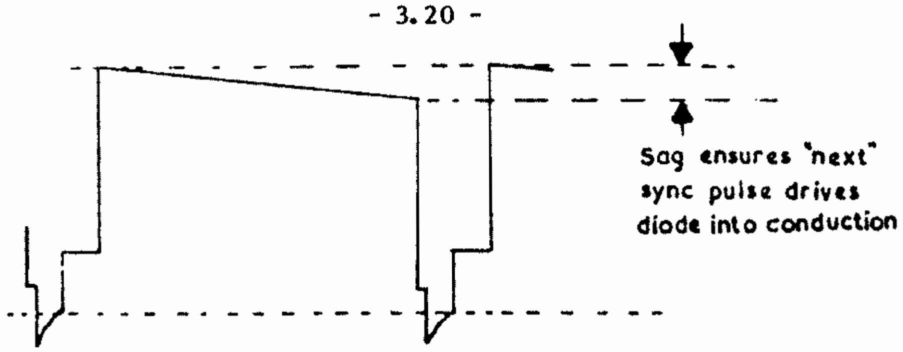


Figure 3.22 Waveform Distorted by Sag

A.C. coupling considerations state that for the output to closely resemble the input a high value of time constant is required. The two requirements thus conflict, one wants a low CR the other a high one. A compromise is reached whereby the time constant is low enough to discharge the capacitor over several lines without introducing too much sag onto the waveform.

Now consider the situation quantitatively. Figure 3.23 shows a circuit in which the practical source amplifier is represented by an ideal voltage amplifier and a resistance Rout. Rout is the effective output impedance of the practical amplifier.

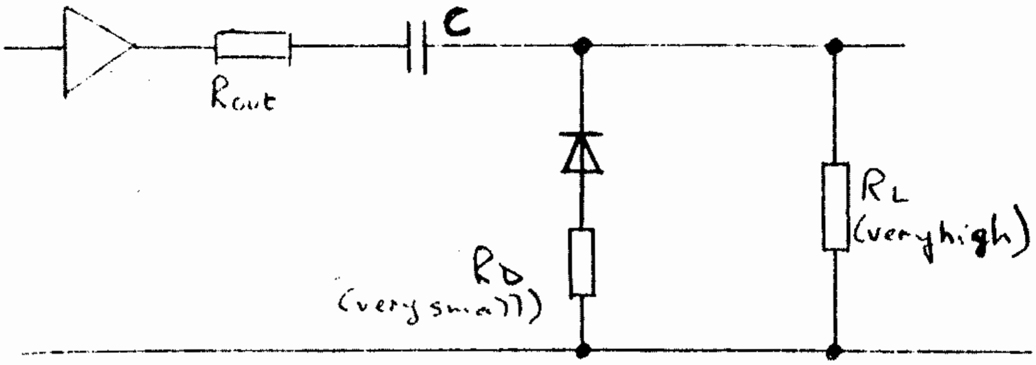


Figure 3.23 D.C. Restorer Using a Practical Amplifier

When no signal is applied to the amplifier, its output will be at a potential of say +V volts. The capacitor will slowly charge up, via RL, to a value V volts and current will then stop flowing. The voltage drop across RL is now 0 volts.

Now consider a video signal of constant average picture level (a.p.l.) applied to the amplifier input. This will give a signal at the amplifier output such that its mean value sits at +V volts. If pure a.c. coupling was used, that is this circuit without the diode, the video signal would appear across RL with its mean level at 0 volts (the common rail potential). The sync tips would be negative by an amount equal to the average value of the signal. The difference between sync tips and the mean level of the signal is designated VS1. Because the diode is present, the output cannot go negative, if it tries, the diode conducts and effectively short-circuits RL. At the amplifier output the sync tips are VS1 volts below the signal mean level and thus the amplifier output is at a potential of (V - VS1) volts. The waveform is shown below in figure 3.24.

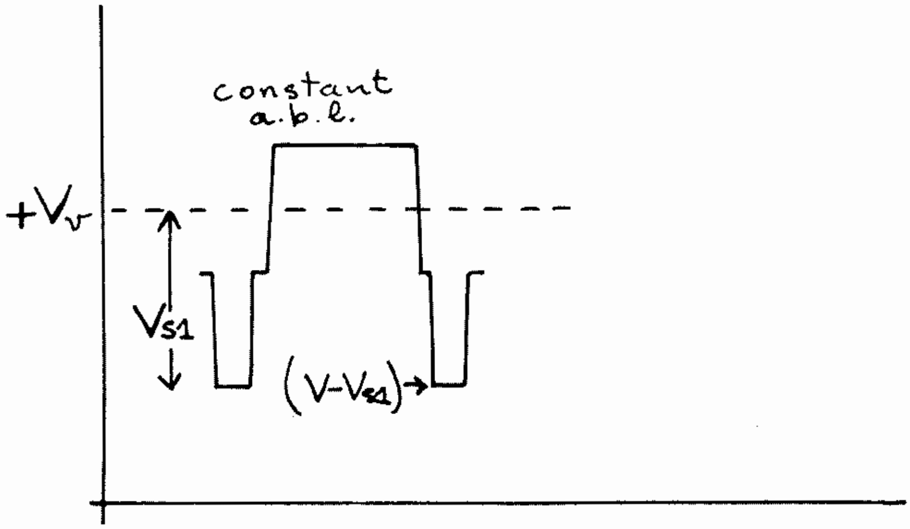


Figure 3.24 Waveform at Amplifier Output

The level situation at sync tips is depicted in figure 3.25.

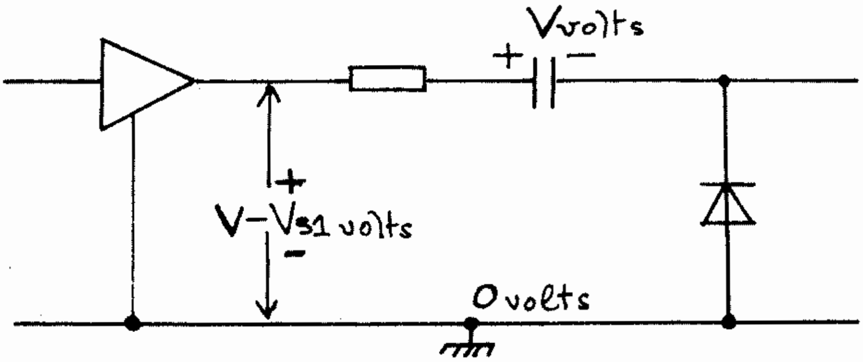


Figure 3.25 Potentials during Sync Tips

This causes the diode to conduct and the capacitor to try and change its charge such that the voltage across it becomes (V - VS1)volts. The discharge path is via the diode and Rout. The internal resistance of the diode is considered small enough to be ignored in this instance. The time constant is (C x Rout), normally this is about 1 µs, this means that the new value of the voltage across the capacitor is reached during the period of the sync pulse. At the end of the sync pulse the signal potential at the amplifier output changes positively and the diode is cut-off.

The capacitor will now attempt to charge, the time constant of the charging circuit is C x (Rout + RL) which is very high. During the active line time the voltage on the capacitor will rise by a very small amount, then, when the next line sync pulse occurs, it drives the amplifier output to its most negative potential, the diode will conduct again on sync tips. Remember, every time the diode conducts it connects the output to 0 volts. This sets the sync tip level at the circuit output to 0 volts, consequently it establishes the black level potential at 30% of video amplitude above 0 volts and white level at 100% of video amplitude above 0 volts.

If the a.p.l. was to change to a higher value, then, at the amplifier output the signal would still sit with its mean level at +V volts but the sinc tips would be at (V - VS2) volts where VS2 is the new mean value of the signal. This is shown in figure 3.26.

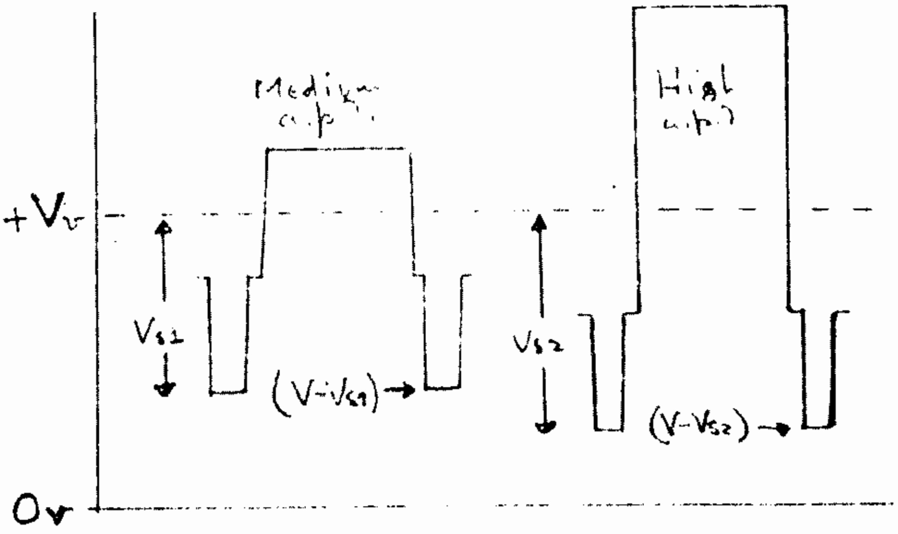


Figure 3.26 Low to High A.P.L. Change

VS2 is greater than VS1 so the difference in level between sync tips and the new mean level is greater than before. Consequently the diode again conducts on sync tips, which are established at 0 volts at the output. Black and white levels are at the same relative potentials and the d.c. component is restored. During the sync pulse period the voltage on the capacitor changes to (V - VS2) volts.

Now consider a change to a signal of lower a.p.l. Again, the signal at the amplifier output sits with its average value at +V volts and an average value of VS3 gives sync tips at a level of (V - VS3) volts. This is shown in figure 3.27.

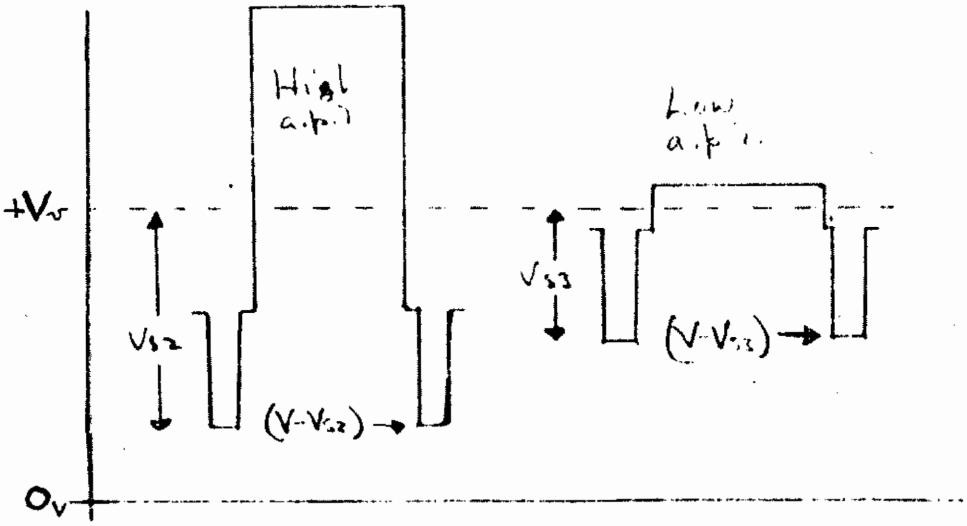


Figure 3.27 High to Low A.P.L. Change

VS3 is smaller than VS2 (and VS1), the capacitor is charged to (V - VS2) volts. The polarity of the voltage on the capacitor is such that it is trying to turn on the diode whilst that at the amplifier output is trying to turn the diode off.

VS3 < VS2 therefore (V - VS3) > (V - VS2) thus the diode does not conduct on sync tips now. This means that the circuit does not work for fast high to low a.p.l. changes.

The diode will not conduct until the votage on the capacitor has risen to a value such that it is greater than (V - VS3) volts. Because of the high charging time constant this may take some considerable time. If the time constant during the active line time were decreased, then high-to-low a.p.l. changes could be accommodated. The disadvantage of doing this is that the time constant of the video coupling circuit is reduced and sag is introduced onto the video waveform. Ideally, of course, there should not be any sag and as in all such situations, a compromise is reached in determining the time constant. A time constant of about 2 ms is typical.

DC RESTORER -TC

Diagrams are shown below depicting various conditions and levels for signals of different average picture levels.

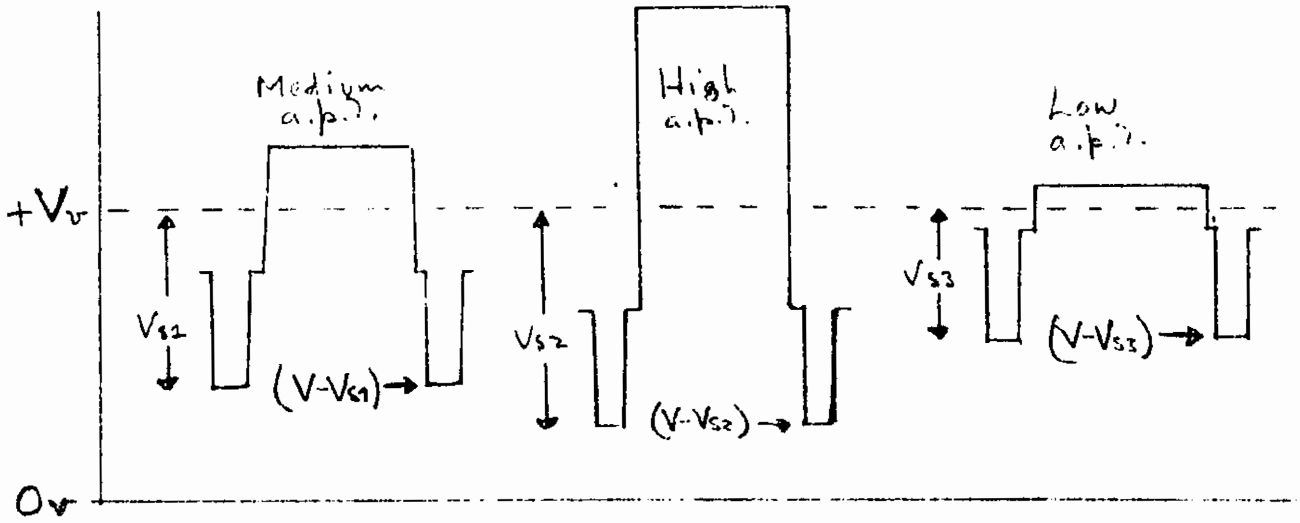


Figure 3.28

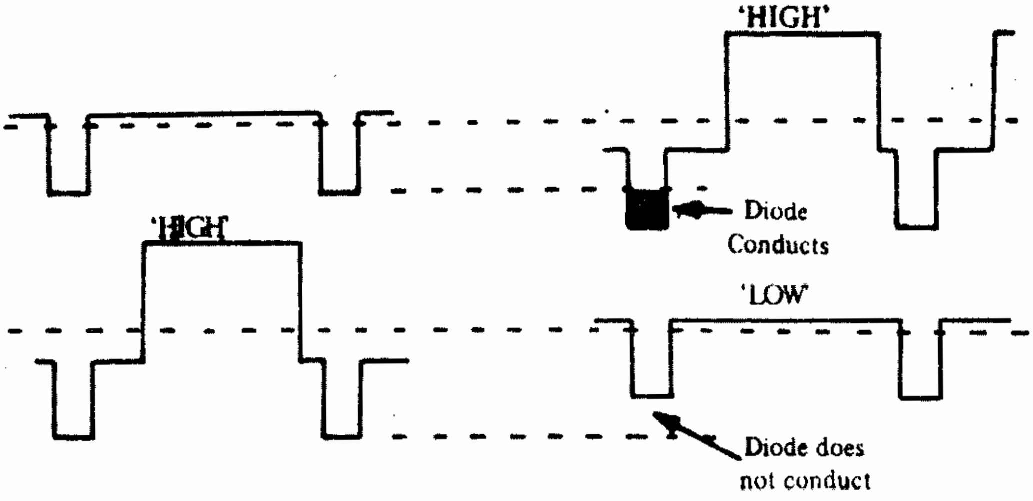


Figure 3.29 D.C. Restorer Performance with Mean Level Change

The effects of d.c. restorer circuits can be shown on the demonstration equipment by considering the situation when a video signal is distorted by the addition of 50Hz hum. The hum causes the d.c. level of the signal to vary, when it rises the diode does not conduct on sync tips. Because the diode only conducts on the most negative part of the waveform, only the sync tips corresponding to the most -ve peaks of the hum are held at 0 volts.
See Figure 3.30.

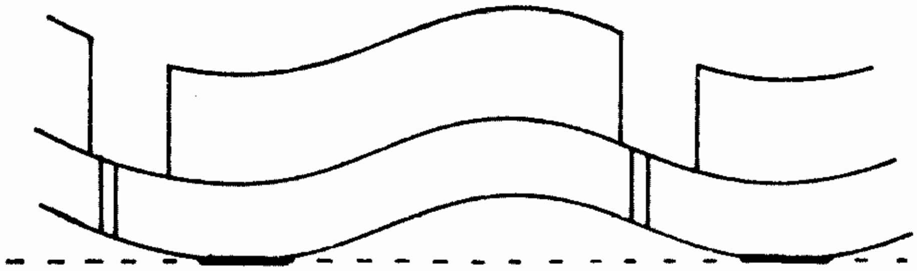


Figure 3.30 Hum and the d.c. Restorer

Display on the demonstration equipment, at field rate, a signal of constant a.p.l., say Test Card, and introduce some hum. Select d.c. restorer with a long time constant. The output waveform will be similar to that in Figure 3.30 where the negative area is slightly flattened but the other parts of the signal still vary with the hum. Shorten the time constant and observe the effect over one or two fields. All the sync tips should be at the same potential. Change the time base speed to monitor several lines, if periods of constant amplitude are selected sag will be observed.

3.4 CLAMPING

The basic problem with the d.c. restorer circuit is that because of the diode action the capacitor cannot be charged as quickly as it can be discharged. This problem could be overcome by substituting a switch in place of the diode and closing it during sync tips. Current could now flow in either direction and any change in a.p.l. could be handled. When the voltage on the capacitor reaches its new value, the switch can be opened.

In practice, the switch is closed during the period of the back porch and not during the sync pulse period. What is the advantage of using black level as the reference rather than sync tips? If the picture-sync ratio is wrong, that is say syncs are crushed, then using them as the reference gives an incorrect black, and consequently incorrect white levels.

Figure 3.31 shows the basic form of a black level clamp circuit.

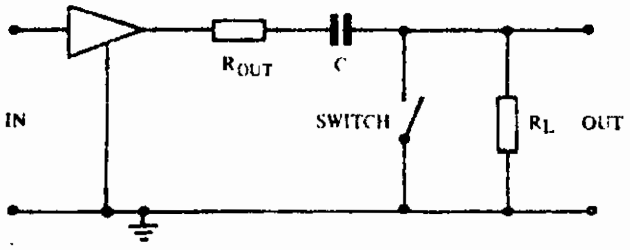


Figure 3.31 The Basic Black Level Clamp

The same approach to understanding the operation of the circuit can be made as for the d.c. restorer circuit. In the absence of a signal, the capacitor charges up to V volts and then, when a signal is applied, the video sits at the amplifier output with its mean level at +V volts. In black level clamping VS (VS1, VS2 and VS3) is to be considered as the voltage difference between mean level and black level. When the switch is closed current can flow in either direction and the voltage across the capacitor can be increased or decreased quickly. When the new voltage across the capacitor is reached the switch can be opened and the d.c. conditions will be maintained because the circuit time constant is long.

In the example just discussed, the time constant when the switch is closed is very short, say of the order of 1 us. This means that the capacitor can change its voltage to a new level in the period that the switch is closed. This appears at first thought to be ideal, but there can be problems. If the back porch is not correct, say due to noise, then the wrong reference level is selected. Noise is normally a random function and clamping line by line to different levels would occur. This causes random horizontal bands to appear across the screen. Lengthening the clamp time constant to a value such that black level errors due to a.p.l. variations are corrected over several lines cancels out the effect caused by random noise. The time constant is increased by connecting a resistor in series with the switch.

Clamps with short time constants are called HARD CLAMPS and those with long times constants are called SOFT CLAMPS. Both types of clamps are used in broadcasting.

Where in a broadcasting system would each type be used?

Write your answer below.

Soft Clamps are used in Condition of poor S/N ratio (response to minor Variation poor)

Hard Clamp. are used with a ~~go~~ clean Vision signal (response to Variation of black level fast)

If the video signal is free from noise a hard clamp would be used, say near to the signal source. If a noisy signal is possible, say at the end of a long distribution chain, a soft clamp is used.

The circuit of a clamp with a resistor in series with the switch is shown in Figure 3.32.

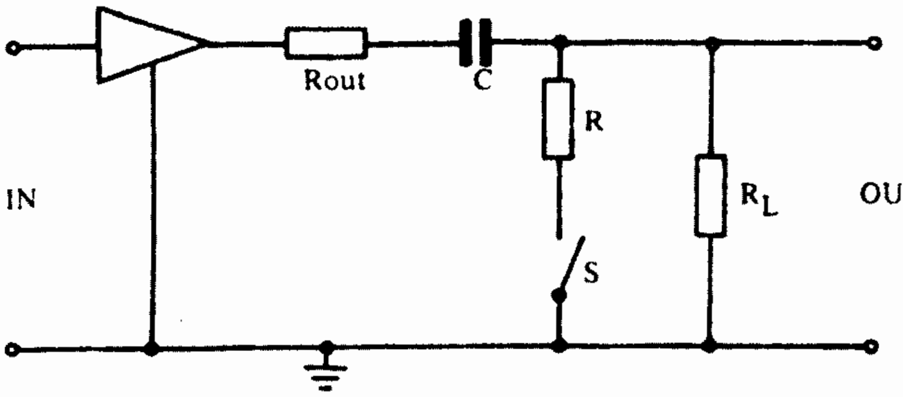


Figure 3.32 Clamp Circuit with Long Time Constant

In practice the switch can take one of many forms. A very common circuit was a bridge network of diodes (semiconductors or valves). Now the most common device is the field effect transistor used as a voltage controlled resistor. When switched on the FET is a low resistance, about 300X, when switched off it is a high resistance, hundreds of kilohms. The switch is controlled by a short pulse, about 3 µs duration, which is timed to occur during the back porch of the video signal. This short pulse is called a CLAMP PULSE.

The trailing edge of sync is often used to generate the clamp pulse.

Another problem with black level clamps occurred when colour television was introduced. The colour sub-carrier (c.s.c.) reference burst consisting of several cycles of c.s.c. is inserted during the back porch where clamping takes place. To prevent the c.s.c. being shorted out by the clamp a filter is connected in series with the clamp switch. The filter is effectively a high impedance at c.s.c. frequency but a low impedance at lower frequencies. Thus the action of the clamp is not affected by the c.s.c. burst nor does the clamp circuit distort the c.s.c. burst. A typical simple clamp circuit is shown in Figure 3.33.

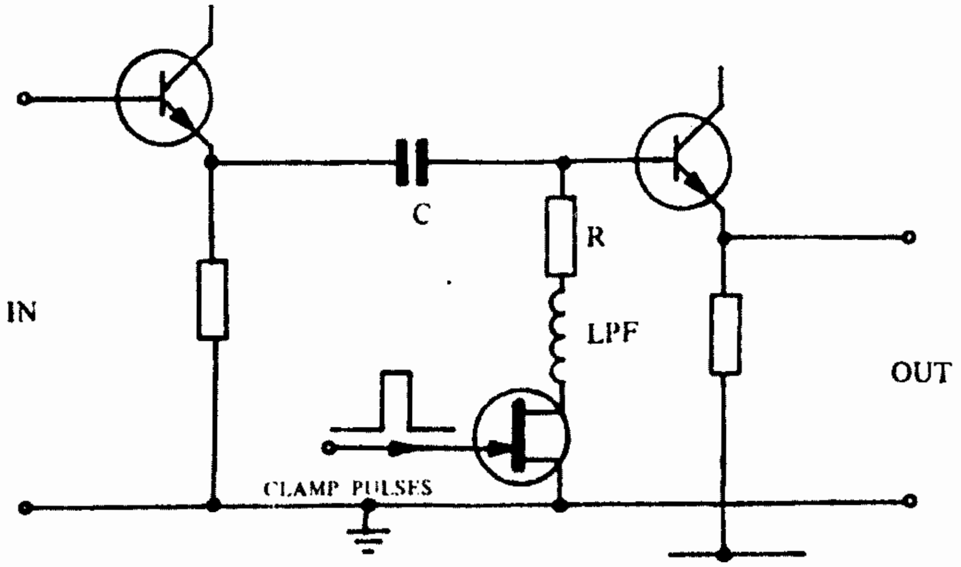


Figure 3.33 A Simple Black Level Clamp Circuit

Various aspects of black level clamping can be shown by use of the demonstration equipment. The split screen facility along with the double trace oscilloscope can show before and after effects. The clamp pulse timing can be adjusted, the clamp pulse and its relative position to that of line syncs can be displayed on the oscilloscope.

First introduce hum on to the video waveform and check the effect of clamping. Then introduce some h.f. noise and observe the effect of different values of time constant.

Adjust the timing of the clamp pulse. The clamp pulse cannot be adjusted to occur before the end of syncs but it can be delayed to occur during the active line time. Do this first of all with a short time constant and then with a long one, is there any difference? If so - why? If not - why not?

SECTION 4

TRANSMISSION STANDARDS AND SIGNAL DISTRIBUTION

SECTION 4 TRANSMISSION STANDARDS AND SIGNAL DISTRIBUTION

4.1 TRANSMISSION STANDARDS

4.1.1 Modulation and Bandwidth

At the transmitting station the sound and the video signals modulate different carrier frequencies. The output of the transmitter modulated by the video signal is called the VISION signal to distinguish it from the video signal.

The large bandwidth required for the video signal requires carrier frequencies in the UHF bands (300 to 1000 MHz), for ease of reception the sound carrier is close to the vision carrier. There are various types of modulation that could be used but most standards use amplitude modulation for the vision carrier, some standards use positive modulation others use negative modulation. The sound carrier can be either amplitude or frequency modulated.

The U.K. 625 line system uses negative amplitude modulation for vision and frequency modulation for sound.

Vision waveforms for the two types of amplitude modulation are shown in Figure 4.1.

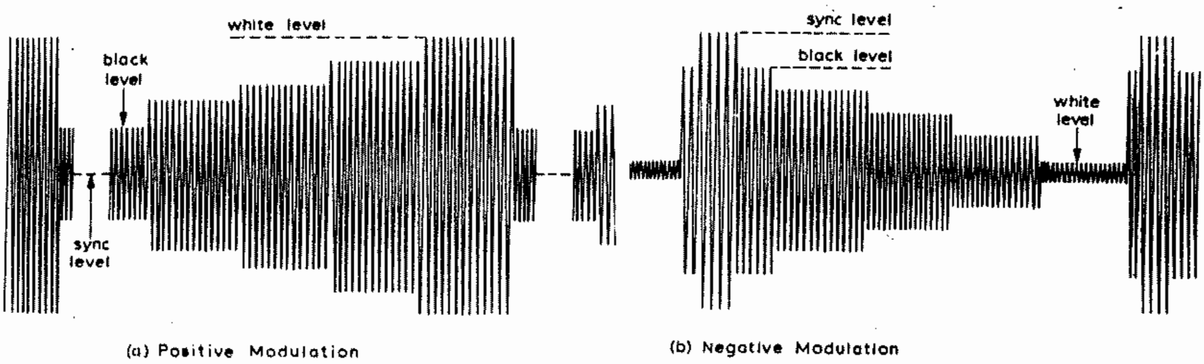


Figure 4.1 Vision Signals for +ve and -ve Modulation

A standard level monochrome video signal is shown in figure 4.2, when it is used to modulate a U.H.F. vision transmitter it produces an r.f. envelope as shown in figure 4.3.

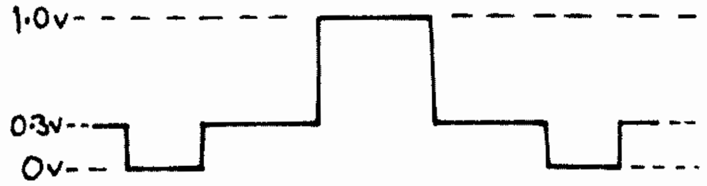


Figure 4.2 Standard Level Monochrome Video Signal

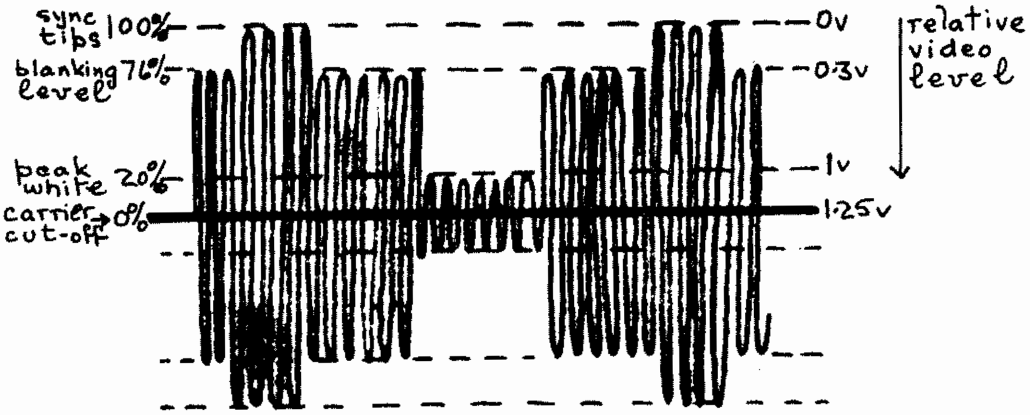


Figure 4.3 R.F. Envelope of a Modulated Vision Transmitter

Peak power, maximum carrier amplitude, occurs at sync tips, this point is taken as 100% carrier. Peak white is set to 20% of carrier and thus puts blanking level at 76% carrier.

If sync tips and blanking level are fixed, the normal condition, there is headroom of 25% of STANDARD VIDEO LEVEL before carrier is cut off. This means that picture level could rise to 0.95 volts, an overall video amplitude of 1.25 volts, before carrier cut-off occurs.

The quoted power of a u.h.f. vision transmitter is the power generated at sync tip level. The ratio of vision:sound transmitter power is 5:1.

With an amplitude modulated system it is possible to obtain an undistorted video signal from a receiver by radiating only one of either the upper or lower sidebands, this is called single sideband transmission (S.S.B.). This considerably reduces the bandwidth required for a television channel. For practical reasons it is easier to send one of the sidebands complete, the carrier signal and in the other sideband only those frequencies that are close to the carrier frequency. This is called vestigial sideband operation (V.S.B.). U.H.F. transmissions transmit the upper sideband complete and a vestige of the lower sideband.

For full double-sideband amplitude modulation the vision bandwidth required would be (2 x 5.5MHz), that is about 11MHz. Room must also be found in the spectrum for the sound carrier.

This situation would require a channel bandwidth of the order of 12MHz.

By using v.s.b. a channel bandwidth of 8MHz is sufficient.

The sound carrier is 6MHz higher in frequency than the vision carrier and thus is placed just above the maximum upper video sideband frequency.

4.1.2 U.K. System Standards

The television system used in the U.K. is called SYSTEM I and some of its basic standards are given in the table below.

No. of Lines	Line Freq.	Video Band-width.	Channel Band-width	Sound carrier w.r.t. V.Carrier	Vision mod.	Sound mod. to
625	15.625kHz	5.5MHz	8MHz	+6MHz	-ve A.M.	F.M.

Table of transmission standards for the U.K. 625 line systems

The UHF bands, Bands IV and V, are divided up into channels spaced 8MHz apart and each channel is identified by a number. The lowest frequency channel is number 21 and the highest is number 68.

Band IV is from 470 to 582MHz [channels 21 to 34] and Band V is from 614 to 854MHz [Channels 39 to 68].

The frequency spectrum of a U.H.F. television channel is shown in figure 4.4.

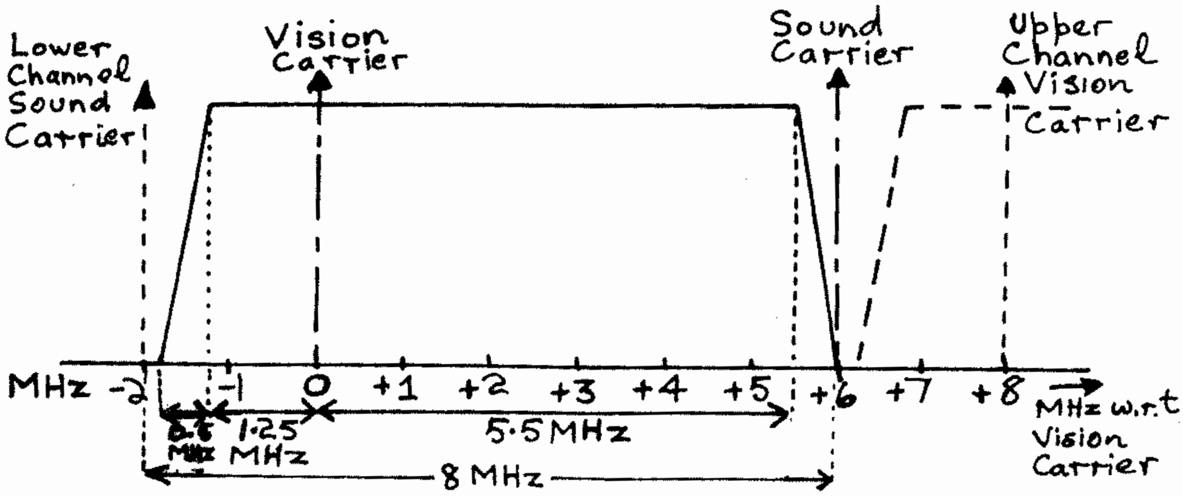


Figure 4.4 Frequency Spectrum of a U.H.F. Television Transmission Channel

Transmitting stations have been designed to radiate four services from the same mast and of equal power. Receiving aerials are made in four different groups called A, B, C/D and E. The four channels radiated by a transmitter are selected to enable one receiving aerial, of the appropriate group, to be used to receive the four services. Transmissions can be either vertically or horizontally polarised.

4.2 SOUND AND VIDEO DISTRIBUTION

The sound associated with a video signal is transmitted separately from the video signal. In the past the two signals were sent by different routes from the studio to the transmitter. Nowadays, the two signals are combined for distribution via the main video distribution network. The sound is converted into a digital code and the coded pulses are then inserted into the sync pulse period of the video signal. The two signals are separated and returned to normal signals at the receiving terminals of the video distribution network.

This system is called Sound in Syncs.

The video distribution network is a combination of video lines and s.h.f. radio links.

SECTION 5

SUMMARY